ENGINEERING NEWS-RECORD

NOVEMBER 15, 1945

work for a flume to carry
for the Deschutes irrigation
t across the Crooked River
n in Oregon (See P. 73)

Featured In This Issue...

SURING CONCRETE BEHAVIOR

OS RIVER RAILWAY BRIDGE

COLUMN STRESS BY DEFLECTIONS

TIMBER RESEARCH DEVELOPMENTS

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NGINEERING NEWS-RECORD

oted to Buildings, Sewers, Waterworks, Bridges, Roads, Dams, Foundations, Earthwork, Flood Control, Public Works, Shipbuilding, Irrigation, Canals, Railroads
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WALDO G. BOWMAN, *Editor* **ALBERT E. PAXTON, *Publisher***

l. 135 NOVEMBER 15, 1945 No. 20

OMING NEXT

esign of a new four-lane suspen- bridge with a 2,800-ft. span to lace the Tacoma Narrows Bridge, ich collapsed in 1940, has now n completed. The design is based a four-year research program in pecially constructed wind tunnel. full-length scale model was built tested to determine, not only effect of wind but the possibility vibration resulting from aerody- ic forces. The design and test- procedure will be discussed in Nov. 29 issue.

Designed in 8-ft. linear modules, erous prefabricated one-story y hospitals have been built in Pacific theater. Constructions sist of a bolted framework of et steel formed to structural pes, and an exterior covering of . wide panels of 24-gage sheet tal, factory punched to permit id assembly. These structures methods of erection will be de- ibed in *ENR*, Nov. 29.

he spillway serving Fontana m has a fall through tunnels where water attains a velocity of more n 100 mph. A concrete bucket- e dissipator of novel design eads this shooting water into a n jet that rises to a height of ft. into the air before it falls into channel below the dam where the ergy dissipation takes places. A port on the design and operation tures will be published in the Nov. issue.

OOKING AHEAD

In an early issue Arthur J. Boase, nager, Structural Bureau, Port- d Cement Association, will de- ibe the design and construction Quitandinha, a vacation resort el in Brazil, which has among er unique features—a roof-top ding field for helicopters, a 152- reinforced concrete ribless dome, 100-ft. rigid frames and concrete sses.

espite remarkable improvements construction theory and practice, re remains the unsolved and vex- problem of one of its essential ments—inspection. Consideration he many obvious faults and short- ings of current inspection prac- suggests that immediate reme- action would be both helpful profitable. This problem and gested measures for improving in- ction practices will be discussed an early issue.

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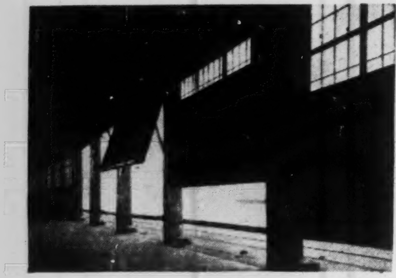
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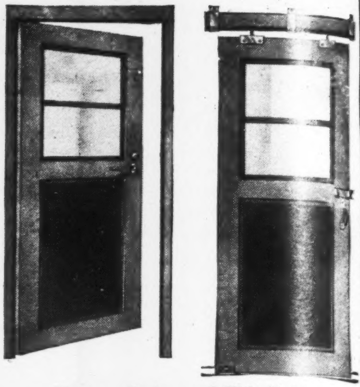
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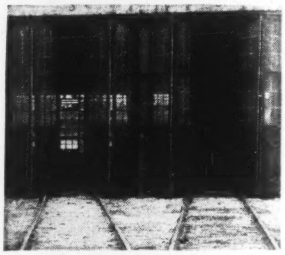
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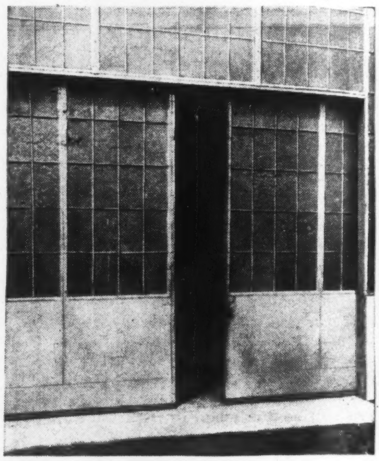
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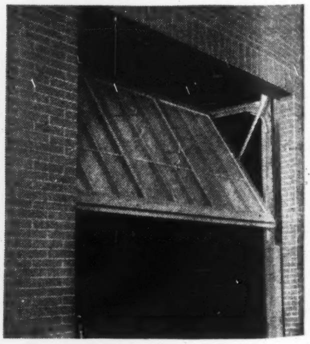
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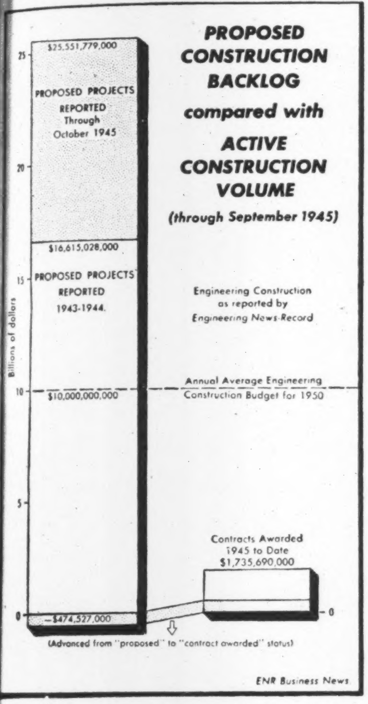
Construction Advances to Active Status

THE CUMULATIVE proposed construction backlog measured from January 1943 through October 1945 is $25,551,779,000. This total remains after $474,527,000 worth of projects that have already advanced to active status of contracts awarded has been subtracted from the proposed construction backlog. During the first ten months of 1945, $8,936,751,000 in proposed construction projects were added to the measured backlog over and above the $474,527,000 that moved out of proposed and into contract awarded status. This $8,936,751,000 in proposed construction projects for a ten month period can be compared with the amount added during the 12 month period in 1943, $5,101,089,000, and in 1944 $11,513,939,000.



Breaking down the $25,551,779,000 backlog geographically, the Middle Atlantic states lead with their $6,357,901,000 forming 25 percent of the country's total. The other sections follow: West of the Mississippi, 22 percent; Far Western, 22 percent; Middle West, 18 percent; Southern, 9 percent; and New England 4 percent. The proposed backlog for public construction, $22,017,232,000, is 86 percent of the total for the U. S., with earthwork and drainage, public building and unclassified construction the leaders by class of work. Private construction, totalling $3,534,547,000, makes up the remaining 14 percent of which commercial and industrial buildings are the leaders.

Of the $474,527,000 that has been advanced to active status during the ten months of 1945, $238,481,000 has been in private construction and $236,046,000 in public construction. Geographically, states West of the Mississippi, lead the advance to active status during the first ten months of this year with $161,203,000 or 34 percent of the U. S. total. Other regions follow with: Middle West 22 percent, Far West, 18 percent, Middle Atlantic, 15 percent, Southern, 7 percent, and New England 4 percent.

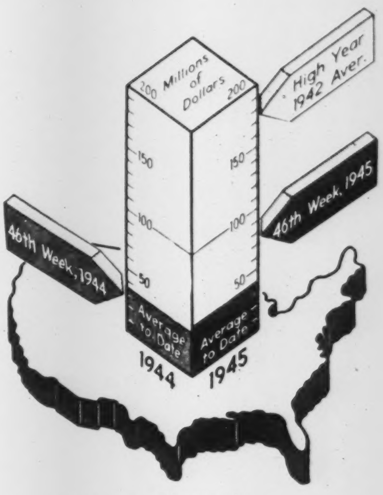
By class of work industrial buildings leads the advance to active status with $143,194,000 or 12.4 percent of its total backlog of $1,153,919,000.

CONSTRUCTION ADVANCE TO ACTIVE STATUS—BY CLASS OF WORK

(Thousands of Dollars)

Class of Work	ENR Measured Backlog of Proposed Construction	% of total	Advanced to Active status (Jan. 1945, to date)	% of total	% of proposed advanced to contract awarded
Waterworks..........	$841,364	3	$22,337	5.0	2.6
Sewerage.............	1,433,336	6	10,764	2.0	.7
Bridges...............	1,112,943	5	4,295	0.5	.4
Earthworks—Drainage.	6,839,401	28	23,048	5.0	.3
Streets—Roads.........	3,632,129	14	7,507	0.5	.2
Public Buildings......	4,400,394	17	112,495	24.0	2.5
Commercial Buildings..	1,657,933	7	48,087	10.0	2.9
Industrial Buildings....	1,153,919	5	143,194	31.0	12.4
Unclassified..........	4,480,360	15	102,800	22.0	2.6
TOTAL, OCT. 31, 1945	**25,551,779**	**100**	**474,527**	**100.0**	**1.9**
Total, Dec. 31, 1944...	**16,615,028**				
Total, Dec. 31, 1943...	**5,101,089**				

CONSTRUCTION ACTIVITY



As Reported This Week to.
Engineering News-Record

CONTRACT VOLUME

Continental U. S. Only
(Thousands of Dollars)

	Week of Nov. 15 1945	Cumulative 1945 (46 wk.)	Cumulative 1944 (46 wk.)
Federal	8,486	716,653	$1,020,825
State & Mun..	11,762	335,073	225,599
Total Public..	20,248	1,051,726	$1,246,424
Total Private.	56,070	893,908.	330,930
U. S. Total...	**76,318**	**1,945,634**	**$1,577,354**

WHERE CONSTRUCTION ACTIVITY ORIGINATED THIS WEEK

Type of Work	Dollar Volume (Thousands) This Week	Cumulative 1945 (46 wk.)	Cumulative 1944 (46 wk.)
Waterworks ..	$538	51,357	$29,713
Sewerage	368	29,998	28,586
Bridges	1,308	39,377	14,767
Highways	6,706	203,184	180,731
Earthwork, Waterways	2,437	50,433	61,874
Buildings, Public	3,617	439,226	592,416
Industrial ...	27,365	503,646	156,426
Commercial .	23,902	281,856	127,993
Unclassified ...	10,077	345,898	384,848

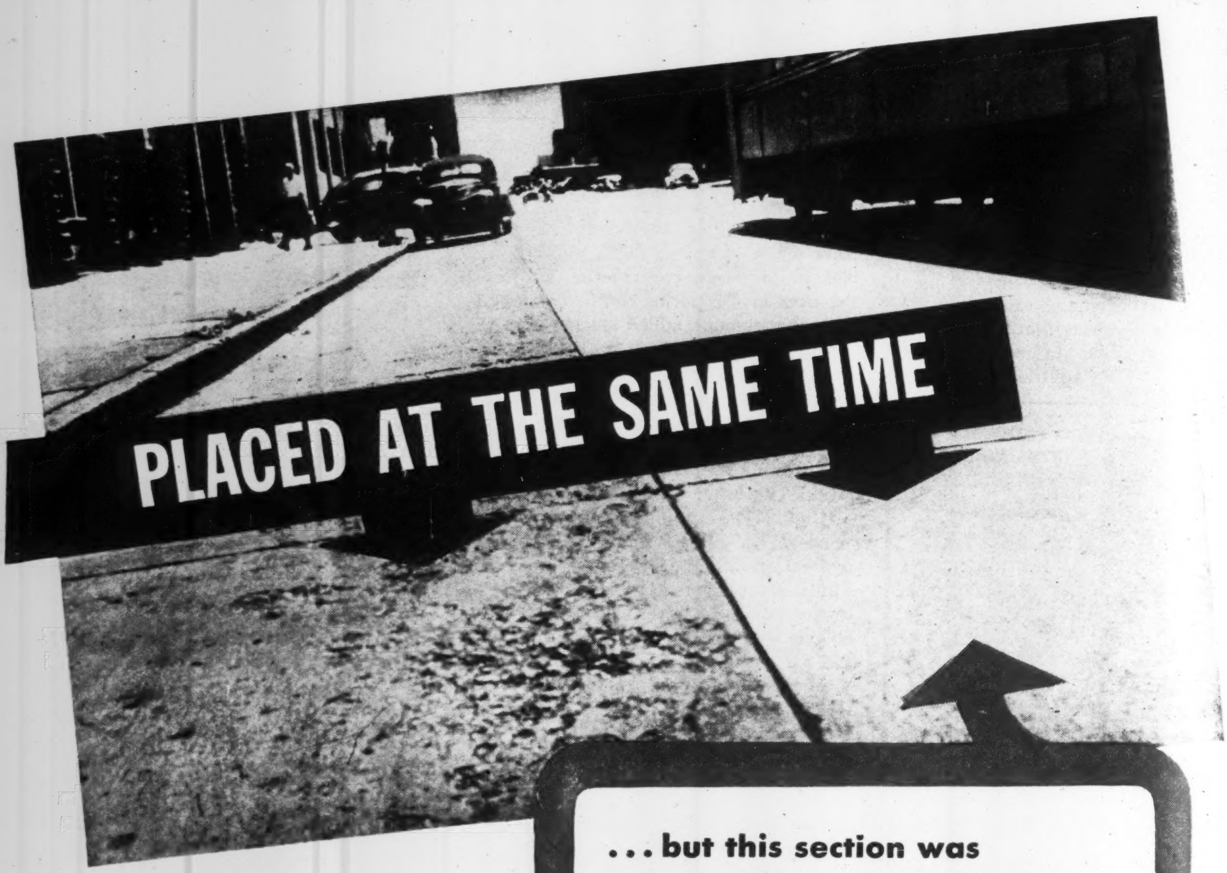
NOTE: Minimum size projects included are: Waterworks and waterway projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.

NEW PRODUCTIVE CAPITAL

	Cumulative 1945 (46 wk.)	Cumulative 1944 (46 wk.)
NON-FEDERAL	$687,851	$417,378
Corporate Securities.	179,430	106,120
State and Municipal.	344,821	166,318
RFC Loans	24,600	61,940
REA Loans	60,000	20,000
Fed. Aid Highway..	79,000	63,000
FEDERAL	$1,049,898	$1,263,800
Total Capital	$1,737,749	$1,681,178

ENR INDEX NUMBERS

Index Base = 100		1913	1936
Construction Cost..	Nov. '45	309.28	148.67
Building Cost......	Nov. '45	240.55	130.00
Volume	Oct. '45	167	73



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ENR-D-28

SUNDAY EVENINGS—American Broadcasting Company (Blue) Network—U. S. Steel's "The Theatre Guild on the Air"

GINEERING NEWS-RECORD • NOVEMBER 15, 1945 • VOLUME 135 • NUMBER 20

ublic works curtailment een in reconversion period

merican Public Works Association is told that nitiation of projects now is unwise because of backlog f private work—High bids are curtailing awards

ith an economist on one hand urg- the desirability of postponing public ks projects during this reconversion iod, and a contractor saying that h work already was being curtailed the refusal of public bodies to award tracts because of high prices, it be- me evident to the delegates at the t annual congress of the American blic Works Association that the pros- cts for catching up with deferred struction needs are not too bright the next year or two.

he views of the economist, Neil R. coby, vice president of the University Chicago, and the contractor, Donald White, president of White Consoli- ed, Chicago, were conceded to be a listic appraisal of the situation, how- r, by the 271 delegates from local. te and federal agencies who attended Nov. 4-6 meeting of the association Chicago.

Contractor's viewpoint

aid Mr. White: "Many public of- als have in all honesty taken a view t construction prices for work to be e next year have risen to a point re these officials refuse to award tracts and feel their construction gram should be deferred."

hile the construction industry of country has the equipment, man- rial forces and financial ability to dertake a program of work next year lling some $7 billion, said Mr. ite, the unsettled labor conditions the shortages of skilled labor might tly reduce this potential output.

hese uncertainties of labor rates, r efficiency and materials prices are cted in prices bid on new work, tinued Mr. White. "We have every on to think that labor scales next r will be substantially higher than e now in existence; in fact, if there shortage of skilled men, rates of pay will be asked by competent men even in excess of the rates established in labor agreements. This latter condition is extremely unhealthy but one that must be taken into account by the contractor who obligates himself to complete a contract."

Questioned on the relationship of estimates today with those on a 1940 price basis, Mr. White said that highway and airport work bids were 20 to 25 percent higher, and that building construction which requires more labor, was about 40 percent higher. In his opinion labor efficiency today is only about half of that prevailing a few years ago.

What an economist sees

Dr. Jacoby declared that in his judgment a serious inflation of prices during the reconversion period is more probable than a serious deflation. Consequently he reached these conclusions about the role of public works during the coming reconversion period:

1. The available evidence suggests that the backlog of private industrial, commercial and residential building is probably large enough, together with non-postponable public construction, to take up all the labor and materials that the construction industry can supply for the next year or two. The initiation of additional public works on a large scale would probably add to the violence of cyclical fluctuations in the construction industry, increase the costs of public construction, and block off some private construction.

2. The vast reserves of liquid assets in the hands of the public and the manifestly large demands for all kinds of goods and services suggest that national economic policy will more probably have to cope with an excess, rather than a deficiency, of aggregate demand, and that postponable public construction activity designed to provide employment will probably not be necessary for several years.

3. Because public policy may have to cope with serious deflation and unemployment as well as with inflation and boom during reconversion, a large amount of public works should be planned right through the blueprint stage in order that construction can be gotten under way promptly, if such work should become necessary.

(*Continued on page* 70)

Col. Stuart M. Weaver, retiring president of the American Public Works Association, counsels president-elect Lloyd M. Johnson, commissioner of streets and electricity, Chicago, on the job ahead.

Public works curtailment is seen

(*Continued from page 69*)

Many persons, said Dr. Jacoby, have fallen into the error of thinking that immediate large outlays on public works are needed to make up an expected "deficit" in the amount of private consumption and investment outlays. This notion has recently gained headway as a result of the extensive discussion of the Murray Full Employment Bill. This bill, he said, relates employment in an oversimplified way to total public and private spending, and requires the federal government to make good any deficiency in private expenditure and investment by public spending, presumably on public works. This view is based on a misconception of the economic problems involved.

The major reconversion problem, in the opinion of Dr. Jacoby, is not the physical task of clearing war materials and machinery out of plants and retooling for civilian production. That job is now well on its way to completion. The real problems are: first, the human problem of training workers in new skills and relocating them in new regions, industries and crafts; and secondly, the economic problem of finding a new price and wage structure that will prevent price inflation, that will hold forth the prospect of sufficient profits so that business will expand and create more jobs, and that will maintain mass spending and mass markets.

To launch a vast public construction program immediately would block rather than facilitate the solution, he concluded, because it would create such competition between private and public interests for yet-scarce construction labor and materials as to raise their prices and choke off much home-building and industrial construction that would otherwise be started.

Walter Swietlik, commissioner of public works, Milwaukee, Wis., expressed the view that public works construction should take second place to other activities during the reconversion period.

Unemployment, he said, has not reached the stage where there is any need for a program of public works. He made these recommendations: (1) Avoid the initiation of projects, the construction of which would compete with private building; (2) hold in abeyance all contracts to be let until prices are lower; (3) devote attention now to maintenance work; and (4) strengthen engineering staffs to be prepared for future needs.

Lloyd M. Johnson, commissioner of streets and electricity, Chicago, was elected president to succeed Col. Stuart M. Weaver, chief of the repairs and utilities section of the Corps of Engineers.

Vice presidents chosen for the coming year were: Maj. Samuel S. Baxter, Corps of Engineers, Philadelphia, (Eastern area); Albert P. Learned, Kansas City (Central area); and Walter Frickstad, Oakland, Calif. (Western area). William Xanten of Washington was elected treasurer. New members of the board of directors are: L. R. Gare, Ecorse, Mich. and Edward J. Cleary, New York.

The Veteran's Award of the association, which recognizes continuous employment of more than 30 years with one city, was presented to:

Carl O. Nygard, superintendent of incineration, Minneapolis, Minn.; Albert G. Walter, superintendent, Water and Electric Department, Dunkirk, N. Y.; Wm. H. Tolles, superintendent of streets, Nashua, N. H.; and Gamble M. Bowers, who is director of public works, Richmond, Va.

Bass resigns from post

Frederic R. Bass, who has been serving the association as executive director during the absence of Maj. Norman Hebden on military leave, asked to be relieved from these duties on Nov. In accepting his resignation the association extolled the leadership of Mr. Bass during the past three years, pointing out that he had undertaken the arduous duties despite previous retirement from the University of Minnesota.

In his final report Mr. Bass pointed out that the membership of the association was now 1,249, an increase of during the past five years.

The board of directors reappointed Major Hebden, who has just been discharged from the Army where he served as a civil affairs officer in Europe, the executive director's post on Dec.

The board also announced that the 1946 convention would be held next October in Fort Worth, Tex.

Brooklyn-Battery Tunnel construction resumed

Work was resumed last week on construction of the $80,000,000 Brooklyn-Battery Tunnel in New York City. Construction was started in 1941 and was to have been completed in 1944 but was halted late in 1942 as not essential to the war. The work is continuing under the original contracts, which required construction of parallel tubes with 31 ft. external diameter cast iron lining.

Geo. H. Flinn Corp. have the Brooklyn end of the work where shield driving is required through soft material. The two bores had advanced 1,200 and 600 ft., respectively, before they were sealed by concrete bulkheads when the work was shut down.

Mason & Hanger Corp. have driven a 24 x 24 bottom drift 2,600 ft. from Battery Park in Manhattan. The two tubes will be enlarged and lined after the drift is completed.

There is to be a ventilation shaft just north of Governors Island and it was originally intended that tunnel headings would be driven each way from the shaft under a separate contract. However, the existing tunnel contracts have been modified to permit the two contractors to complete the tunnel, which has a total portal length of 9,117 ft.

Work on the project is now about 20 percent complete and it is expected that construction of the tunnel will be finished in about three years. Ralph Smillie is chief engineer of the New York City Tunnel Authority, which is building the facility.

President seeks action on aid for planning

The House Appropriations Committee has been requested by President Truman to expedite consideration of recommendation that the Bureau of Community Facilities of the Federal Works Agency be provided with $50,000,000 to aid local planning groups (*ENR* Oct. 25, vol. p. 556). The President has also recommended that the bureau be empowered to enter into contract obligations to the extent of $57,500,000 additional.

In May (*ENR* May 10, vol. p. 675) the agency was provided with $17,500,000 for aid to local groups planning public works projects. Most of this money has already been allocated and requests are on hand for much additional help.

In making his request the President said, "the matter of advance planning is one in which I have always had a close, personal interest. To have available for immediate construction a well developed and completely planned shelf of worthy public works projects is the best insurance against the waste which results when a program of construction is undertaken without detailed drawings and specifications being available. The fact that the law requires the repayment to the Treasury of advances when construction is undertaken tends to insure that the public works planned by the use of such funds are needed public projects of worthwhile character as the local communities are thereby using their own credit to finance this work."

Manning succeeds Moreell as chief of Bureau of Yards and Docks

ew boss of Navy's civil engineering activities has been field rector of much of its wartime construction—Vice Adm. Moreell oves up to head material supply for entire Navy.

r Admiral John J. Manning has nominated by President Truman to hief of the Bureau of Yards and s, U. S. Navy, with the permanent of rear admiral. The appointment e for a period of four years start- Dec. 1.

miral Manning succeeds Vice Ad- Ben Moreell, chief of the bureau December, 1937, and now replac- Vice Admiral Sam M. Robinson, of the Material Division in the of the Assistant Secretary of the

miral Manning, 52, has been a ber of the Navy's Civil Engineer since 1918, and during the war ccupied positions of top responsi- in the tremendous bureau and e organization that was developed ndle the world-wide construction of shore facilities. From December, to November, 1942, he was direc- f the Bureau's Construction Divi- from then until June, 1945, he director of the Atlantic Division. ing, among other things, all activi- n the European and Mediterranean ers; and from last June to date he been director of the Eastern Pacific sion, that is, of everything east of m.

Rear Admiral J. J. Manning

graduate of Rensselaer Polytechnic tute at Troy, N. Y., in 1915, where so attended the Naval Academy for ort time before receiving his first au of Yards and Docks assignment—at Guantanamo Bay, Cuba. Thereafter he served at Newport, R. I., Pearl Harbor and Philadelphia, and from 1937 to 1941 was head of the Fleet Facilities Division in the bureau at Washington. Admiral Manning's career was the subject of an article in *ENR* Dec. 7, 1944.

Vice Admiral Ben Moreell

Chief for eight years

Admiral Moreell's eight year term as Chief of the bureau during which he earned the highest praise, both from within and outside the Navy, as one of our greatest wartime leaders, is well and widely known. The program carried out under his direction represented an investment of $10 billion, or 15 times the value of naval shore establishments existing before the war. He also organized and headed the Seabees, whose personnel grew to an organization of 10,000 officers and 240,000 men. Admiral Moreell was a 43-yr. old commander when he was made chief of the bureau in 1937, and in 1944, at the age of 51, he became the youngest vice admiral in the Navy and the only C.E.C. officer ever to attain that rank.

A graduate of Washington University, St. Louis, Admiral Moreell came to the Navy through a competitive examination in 1917. Subsequently he served in the Azores, Haiti, Norfolk, Bremerton and Pearl Harbor, among other places. In the design department of the Bureau, Admiral Moreell developed into one of the country's outstanding authorities on reinforced concrete. Active in the affairs of the American Society of Civil Engineers and the American Concrete Institute, he has served as president of the latter, and in 1942 was elected an honorary member of the A.S.C.E. In his new position on the staff of the Assistant Secretary, Admiral Moreell will occupy one of the most responsible posts in the U. S. Navy organization.

◆

U. S. Forces building airfields in Arabia

The U. S. Army Engineers Sept. 1 started construction of airfield facilities in Saudi Arabia estimated to cost $4,000,000, the War Department revealed last week. When the project is completed the Air Transport Command route from Egypt to India will be shortened by 250 miles by passing the present stop at Abadan at the head of the Persian Gulf. The new facilities may be in operation by May, 1946.

Major portion of the construction is an airfield at the town of Dhahran, on the Persian Gulf near Bahrein Island and the American oil fields, but an emergency field is also being built at Lauqa, a town not far from Dhahran. In addition, navigational aid facilities are planned at the interior towns of Hafar al Batin and Maan.

All construction equipment needed for the project is either on hand or en route and, as of Nov. 6, 80 percent of the required material was on the job or on its way. Because local building supplies and prefabricated structures already available in the theater are being used, no materials will be imported from the United States.

At the Dhahran airfield a principal runway 150 x 7,000 ft. is planned, with a secondary runway measuring 150 x 6,000 ft. The runway pavement, which is designed for a 60,000-lb. wheel load, will consist of a 9-in. compacted shale base and a 3-in. rock-asphalt surfacing.

A total of 53 buildings will be constructed, including 29 prefabricated steel huts. Six buildings with native stone rubble masonry walls and timber roof trusses are also planned.

As of Nov. 1, there were 14 officers, 1 warrant officer, 83 enlisted men, and 45 U. S. civilians on the job. At that time nearly 900 Italian civilians were also employed. It is planned that by January 1, 1946, no enlisted men will remain on the project. Qualified enlisted men eligible for discharge and willing to remain on the job will be hired as civilians, while other American civilians needed will be secured from the U. S.

ENGINEERING SCHOOL NEWS

Structural research lab at University of Washington—New dean at Notre Dame—Dam studies at Minnesota for Houston, Tex.

A new civil engineering building to be built at the University of Washington, Seattle, includes an 80 x 100-ft. section laid out as a structural research laboratory. The new building—a brick-faced, reinforced concrete structure—is to cost $800,000. Of this, $300,000 is allotted to the laboratory for which new testing equipment is now on order. Construction is under way and is to be completed by the end of the year.

One of the rooms, 35 x 45 ft. in plan and 20-ft. high, is designed for a wind tunnel with a throat some 5 x 8 ft. in size. One of the first to be built for this purpose, this tunnel is to be used for testing bridge section models to determine aerodynamic stability. There will be the usual machines for testing materials in tension, compression, torsion and under impact as well as equipment for photoelastic tests.

The tension-compression complement will include four hydraulic testing machines rated at 60,000, 120,000, 300,000 and 2,500,000 lb., respectively. The largest of these, now being built by the Baldwin Southwark Division, Baldwin Locomotive Works, will cost about $140,000 and will have a clear space for test specimens 10 ft. wide and 20 ft. high. For this machine there is a specially designed 4-story section and a separate foundation for the machine itself. This was necessary to permit of testing long trusses or girders whose length exceeds that of the base of the machine. The separate foundation will be an 800,000-lb. concrete monolith to which the machine will be bolted down by 3-in. bolts imbedded 7 ft. in the concrete. By opening doors on opposite sides of the building space will be available for testing girders or trusses at least 125 ft. in length.

Work carried on in the laboratory will be under the direction of Prof. F. B. Farquharson of the University of Washington faculty.

Karl E. Schoenherr has been appointed dean of the college of engineering at the University of Notre Dame. Schoenherr, former naval architect at the D. W. Taylor model basin, Carderock, Md., succeeds Col. D. C. Jackson, who resigned when he entered the service in 1942. Raymond Schubmehl, who has been acting dean, will remain as assistant dean.

The new dean received his primary and secondary education in Karlsruhe and Durlach, Germany. He was graduated from the Massachusetts Institute of Technology and received an M. A. degree at George Washington university. Upon graduation he joined the staff of the U. S. model basin as junior engineer and advanced to naval architect.

J. Wesley Williams, on the instructional staff at Duke University since 1937, has been promoted to assistant professor of civil engineering. A graduate of Georgia Tech, his professional career includes service with the R. H. Bouligny Construction Company of Charlotte, N. C., and with the office of the Army Engineer of the Charleston, S. C., district.

Dean S. S. Steinberg of the college of engineering of the University of Maryland, has returned from a good-will tour of Latin America, where he made a survey of engineering schools on a trip sponsored by the Department of State. He visited institutions and conferred with engineers in Colombia, Ecuador, Peru, Chile, Argentina, Uruguay, Brazil, Venezuela, Panama, Costa Rica, Mexico, and Cuba.

The other purposes of his trip, according to Dean Steinberg, were to establish closer relations between engineering educators of Latin Ame and those of the United States, a as between their respective engine societies; to arrange for exchang professors; and to provide for a w interchange of engineering and nical literature.

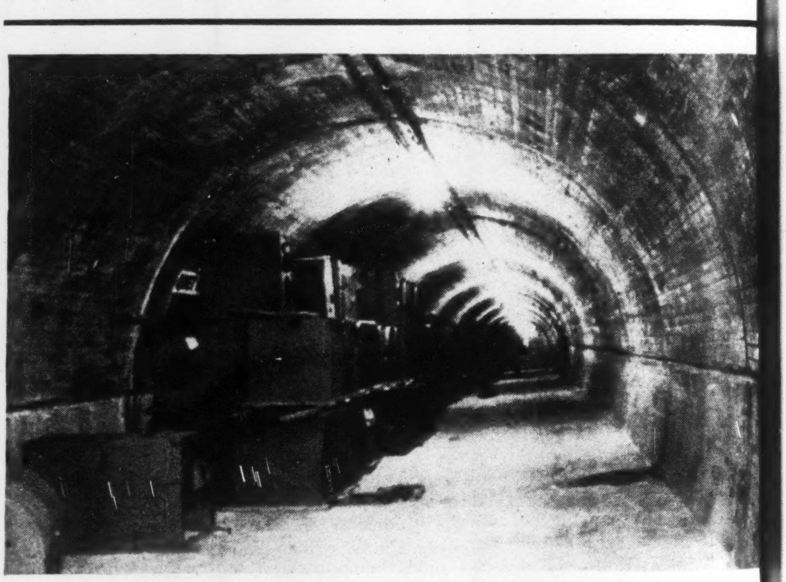
For this trip Dean Steinberg designated the official represent of the Society for the Promotion of gineering Education, the American ciety of Mechanical Engineers, and American Society of Civil Engineer

Facilities of the St. Anthony F hydraulic laboratory of the Univer of Minnesota are being used in exp ments to determine the best poss kind of dam to be built on the Jacinto River for Houston, Tex., to k the city's water supply in even bala throughout the year.

Lorenz G. Straub, director of the l oratory, is in charge of the large periment which got under way this and will be completed by spring. As ing him are members of his staff at laboratory which has been establis on Hennepin island in the Mississi River in Minneapolis.

At present, clay from the bottom the San Jacinto River, various types spillways and a scale-model of the dam itself are being tested in the draulics laboratory.

(*Continued on page* 128)



Navy air-raid shelter at Bremerton revealed

The existence of a concrete air raid shelter at Puget Sound Navy Yard, Bremerton, Wash., built to hold 10,000 persons was revealed by the Navy Department last week. The shelter is comprised of a 1,650-ft. main tunnel with four portals. Its existence had not previously been announced publicl

One of the four portals has been co verted into a telephone center for ship pe sonnel, another is being turned into a ship service store. The main tunnel, shown above is used as storage space.

Site survey planned for a second Bay bridge

Preliminary work on a second San Francisco-Oakland Bay Bridge will be started soon when the California State Board of Public Works begins a comprehensive engineering and financial survey as directed on Oct. 30 by the State Toll Bridge Authority. It is estimated the survey will cost $115.000, of which $40,000 has already been appropriated. The purpose is to find relief for traffic congestion on the present $78.000,000 trans-bay span. On completion of the double-decked structure in 1936, engineers believed its capacity to be 80,000 automobiles per day. Present daily average is 71,000 cars with a 24-hr. record set recently at 78,646. The average daily traffic figure is about 10,000 more than during gas rationing.

Possible sites for a second bay-spanning bridge have not been discussed officially. Charles H. Purcell, director of public works, said five years probably would be required to complete plans, specifications and to build any proposed bridge.

At the present rate of traffic, bonded indebtedness on the existing bridge will be liquidated by Sept. 1952, three years earlier than previously had been expected.

A legal obstacle confronting possible construction of a second bay bridge is a written agreement with bondholders of the present span that without their two-thirds vote no bridge or tube can be built within ten miles of the present structure. However, a spokesman for the syndicate that underwrote the debentures said he felt certain that consents from the requisite number of bondholders could be obtained if it could be shown that the supplemental bridge would not impair the financial prospects of the present span.

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Mexican water treaty put into operation

Documents completing ratification of the water treaty between this country and Mexico were exchanged last week in Washington, thus putting into effect the treaty signed Feb. 15, 1944 (*ENR* Jan. 25, 1945, vol. p. 123).

The treaty calls for construction of three large storage dams on the international section of the Rio Grande jointly by the two governments, construction of Davis Dam on the Colorado by the United States, (already under way) and construction within the next five years of a Mexican diversion dam along or below the international section of the Colorado, also levees and drainage structures to protect lands north of the border at the expense of Mexico. If the diversion dam is built across the international section of the river, the United States agrees to build a canal from the Arizona end to serve irrigation canals in the state of Sonora —the cost to be paid by Mexico.

Other dams for flood control may be built when approved by the two governments, and the commission is authorized to continue the channel improvement work.

Under the treaty, the present International Boundary Commission becomes the International Boundary and Water Commission. Each national section will be headed by an "engineer commissioner". The present commissioners are Lawrence M. Lawson (United States) and Rafael Fernandez McGregor (Mexico).

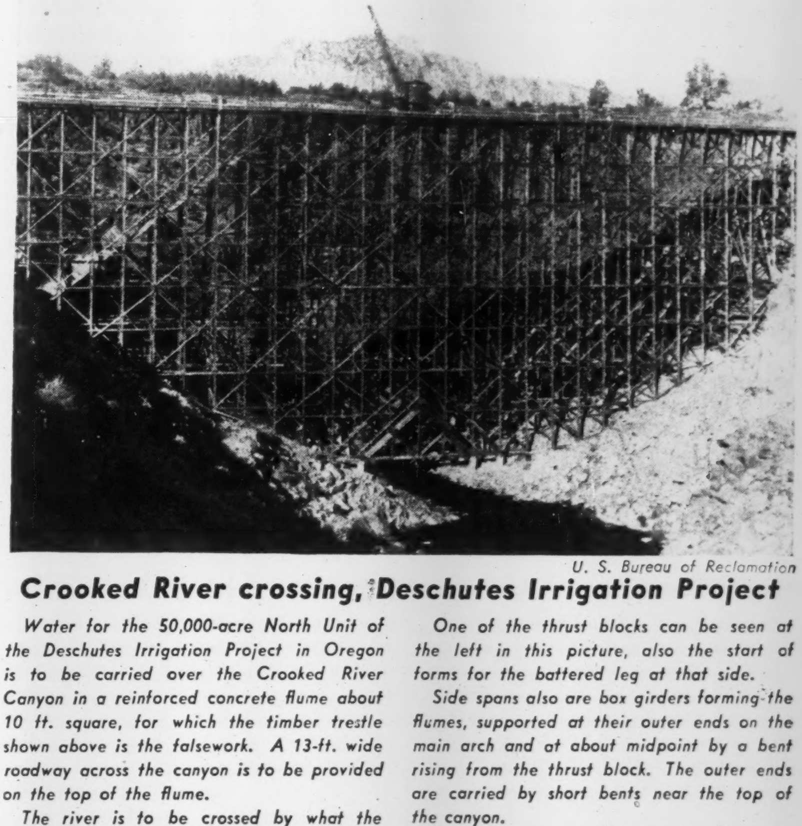
Memphis bridge bids rejected as too high

On Nov. 5 the Memphis and Arkansas Bridge Commission announced that it had rejected all four bids submitted for the construction of the superstructure of the new four-lane Mississippi River Bridge at Memphis, Tenn. (*ENR*, Nov. 8, vol. p. 626).

E. H. Crump, commission chairman, said the bids were "about $600.000 too high" and that no new bids would be received for at least six months.

American Bridge Co. of Pittsburgh, Pa., was the low bidder for the job, underbidding three other construction companies with an offer to build the superstructure for $3.260.189.

Other bids were: Bethlehem Steel Co., $3,487.000; Harris Structural Steel Co., $3.405.740; and Mt. Vernon Bridge Co., $3,545,770.



U. S. Bureau of Reclamation

Crooked River crossing, Deschutes Irrigation Project

Water for the 50,000-acre North Unit of the Deschutes Irrigation Project in Oregon is to be carried over the Crooked River Canyon in a reinforced concrete flume about 10 ft. square, for which the timber trestle shown above is the falsework. A 13-ft. wide roadway across the canyon is to be provided on the top of the flume.

The river is to be crossed by what the engineers of the Bureau of Reclamation characterize as a "modified concrete arch" of 266-ft. span. This will be made up of two sloping box girders extending on about a 45-deg. angle from thrust blocks on each side of the valley up to the box flume where they become integral with a 124-ft. section of the flume itself, which forms the central part of the "arch".

One of the thrust blocks can be seen at the left in this picture, also the start of forms for the battered leg at that side.

Side spans also are box girders forming the flumes, supported at their outer ends on the main arch and at about midpoint by a bent rising from the thrust block. The outer ends are carried by short bents near the top of the canyon.

The Deschutes project is being built by Region No. 1 of the U. S. Bureau of Reclamation under the general direction of Frank A. Banks, director, and R. J. Newell, associate regional director. C. H. Spencer is construction engineer on the project, which is near Bend, Ore.

The flume is being built by David A. Richardson of Santa Cruz, Calif.

Contractor representatives inspect worn out engine parts at the Mack Manufacturing Co.'s maintenance school in Long Island City. Charles Drum, chief service engineer for Mack (third from left) is shown indicating examples of engine failure resulting from improper lubrication.

JOBS OF THE WEEK

BANK BUILDING, Houston, Tex.

W. S. Bellows Construction Co., Houston, Tex., has been awarded a contract for a 24-story bank by the City National Bank, Houston, at $4,000,000. Finn & Cummins, Houston, Tex., are the architects.

DEPARTMENT STORE, Houston, Tex.

Frank Messer & Sons, Inc., Cincinnati, Ohio, has been awarded a contract to build a department store for Foley Brothers, Houston, to cost $4,500,000. E. E. Ashley, New York, N. Y., is the consulting engineer.

GASOLINE REDUCTION PLANT, Burrel, Calif.

Bechtel-McCone Corp., Los Angeles, Calif., will construct a 30,000,000 cu. ft. capacity gasoline reduction plant for General Petroleum Corp., Los Angeles. The estimated cost is over $2,000,000.

MALT HOUSE, Greenfield, Wis.

Froedtert Grain & Malting Co., Inc., Milwaukee, awarded a contract to construct a 160x280-ft. malt house to Walter W. Oeflein, Inc., Milwaukee, at $5,500,000. F. F. Drolshagen, Milwaukee, is the architect. V. K. Boynton, Milwaukee, is the engineer.

AUTO BODY MANUFACTURING PLANT, Hamilton, O.

Fisher Body Division, General Motors Corp., Detroit, Mich., awarded a contract for the substructure for an auto body plant, grading, roads, parking aprons, railroad, water supply and sewerage to Frank Messer & Sons, Cincinnati, at an estimated total cost of $2,016,000. Albert Kahn & Associates Architects & Engineers, Inc., Detroit, Mich., is the engineer and architect.

PLANT and OFFICE, Indianapolis, Ind.

Carl M. Geupel Construction Co., Indianapolis, Ind., has been awarded a contract for a manufacturing plant, office, warehouse and loading docks by E. C. Atkins & Co., Indianapolis, at an estimated cost of $1,500,000 to $2,000,000.

Note—Additional bidding and contract news on many projects large and small, including the above items, appear in the Construction News section beginning on page 209.

Equipment men study construction problems

A 2-week course in construction problems, featuring lectures and discussions by 44 representatives of construction equipment manufacturers, engineering societies, public works officials, contractors and other experts in construction, was held in the Engineering Societies Building, New York City, Oct. 22 to Nov. 3 for a group of sales engineers of the Shell Oil Co., Inc., specializing in contractor sales.

During the twelve 8-hour sessions, the entire emphasis was upon the acquisition of technical knowledge related to the problems of the contractor with whom the engineers deal.

The object, as stated by James M. Morrison, head office representative in charge of Shell's contractor sales department, was "to assist the contractor representative in learning just how he may go about setting up a professional approach that will result in an efficient and economically intelligent selling procedure."

C. B. Singleton, manager of national sales, opened the session. Typical of the instruction given was a movie-illustrated lecture by R. D. Evans, chief engineer of R. G. LeTourneau, Inc., on the operation and maintenance of earthmoving equipment. Rankin Martin, resident vice-president of the Standard Accident Co., spoke on bonding and insurance of public work contractors.

Other speakers included L. W. St. James, New York manager of the Thew Shovel Co.; Lon R. Smith, sales engineer of Hercules Motors; Elsie Eaves, manager of research, *Engineering News-Record;* Frederick C. Lyford, assistant to the chairman of the board of Merritt-Chapman & Scott Corp.; Frank Barnes, cons't mgr. of Merritt-Chapman & Scott; E. H. Dickenson, director of rock drill service for Ingersoll-Rand Co.; Vincent B. Smith, associate editor, *Construction Methods,* Col. C. E. Boesch (retired), head engineer, North Atlantic division, Civil Works Operations, U. S. Engineers; William N. Carey, secretary of the American Society of Civil Engineers; and Kenneth R. Park, manager, sales development division, Caterpillar Tractor Co.

The course included visits to the Mack Truck School at Long Island City, where Charles Drum, chief service engineer of the Mack Manufacturing Co., talked on lubrication problems. There was a visit also to the H. O. Penn Machinery Co. shop at 140th Street and East River, where Wilmot Sandham, chief service engineer, talked on fuel and maintenance problems of Caterpillar diesels.

OBITUARY

Forrest W. Jacoby, construction engineer of Weirsdale, Fla., who was prominent in engineering circles throughout Florida, Georgia and South Carolina, died Oct. 31 in Atlanta, Ga.

D. Hewitt Wood, 74, civil engineer, bridge builder and civic leader, died at Chattanooga, Tenn., Nov. 3. Mr. Wood became associated with the late H. W. Converse as chief engineer for the Converse Bridge Co. in 1895 and subsequently became president of the Converse Bridge and Steel Co. when it was reorganized in 1914. During his long connection with that company, he designed and erected many large steel bridges throughout the South.

John Brazos, 71, secretary of A. Brazos & Sons, Middletown, Conn., veteran road-building concern and general contractors, died Oct. 28. Mr. Brazos, a native of Middletown, was in the general contracting business with his brother all of his business life.

Horace E. Hildreth, 71, civil and mining engineer died at Cambridge, Mass., Nov. 7. He was graduated from Massachusetts Institute of Technology in 1901, in civil engineering. From 1901 to 1910 he was engaged in bridge design and construction with the New York, New Haven & Hartford, and the Pennsylvania railroads. Later he entered business and manufacturing fields.

Jesse Addison Howland, 75, president of Jesse A. Howland & Sons, Inc., contractors, Seabright, N. J., known along the Atlantic seaboard for his jetties, seawalls and other beach protection constructions, died Nov. 6.

In 1928 Mr. Howland made a survey of the New Jersey seacoast to determine necessary protection against storm damage and erosion. He built the Sandy Hook seawall and jetties at the Manasquan Inlet, Monmouth Beach, Asbury Park and Ocean City, in New Jersey, and at Indian River, Delaware.

Thomas Benson Downer, Alhambra, Cal., city engineer for the past 25 years, died Oct. 28 at Reno, Nev. He was 77. Mr. Downer, as a civil engineer, took part in the construction of the city's aqueduct.

Ira B. Castillow, 58, civil engineer at the Firestone Tire and Rubber Co., Akron, Ohio, for 23 years, died Nov. 6.

Clyde A. Walb, 67, president of the American Steel Dredge Co., American Steel Supply Corp., and General Dredging Co., Fort Wayne, Ind., and past president of the Indiana Society of Professional Engineers, died Oct. 30.

Richard Alexander Polglaze, of the engineering firm of Polglaze & Basenburg, died in Birmingham, Ala., Nov. 3. He was president of the Warrior Water Co., and a past secretary of the State Registration Board for Engineers and Land Surveyors. He was a graduate of the Alabama Polytechnic Institute.

C. C. Votapka, 46, assistant area engineer with the U. S. Army Engineers at Onawa, Iowa, died recently in that city. For years he had been an engineer on Missouri River development projects, and was previously stationed at Kansas City and Nebraska City.

William B. Raymond, for nine years engineer on construction of the Welland Canal, died in Toronto, Ont., Nov. 4.

John Edward Greenland, 42, president and general manager of the Ontario Construction Co., Ltd., died at Orillia, Ont., Nov. 5.

Charles S. Bennett, 54, chief engineer of the National Harbors Board at Halifax, N. S., died Nov. 3. Mr. Bennett, a graduate of the University of New Brunswick, for 15 years was Dominion Public Works Engineer at Saint John, N. B.

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"Priority" orders to absorb surplus equipment

The American Road Builders Association reports that at a recent conference in Washington it was stated by officials of the Surplus Property Administration that orders from priority organizations (federal, state, county and city governments, etc.) probably would take up all new construction equipment declared surplus—estimated to be approximately $12 million worth.

Repair parts are said to be the greatest problem in the construction equipment branch of SPA. Large quantities of spare parts have been declared surplus and are expected to be turned over to SPA at any time. Many items included are those which have not been manufactured lately for general use but which were needed for war work. It is said that manufacturers' recommendations should be sent to J. V. McCullough, Director, Construction Equipment Branch, Consumer Goods, SPA, Railroad Retirement Building, Washington 25, D. C.

Fred H. Fowler dies; West Coast consultant

Frederick H. Fowler, 66, prominent consulting engineer of San Francisco and a past-president of the American Society of Civil Engineers, died at his home in Palo Alto, Calif., on Nov. 7.

A native of Fort Custer, Mont., Mr. Fowler was graduated from Leland Stanford University in 1905, where he also taught civil engineering for a year, after two years of active practice. From 1910 to 1922 he was hydro-electric engineer and district engineer for the U. S. Forest Service at San Francisco, serving also as a representative there for the Federal Power Commission.

During World War I, Mr. Fowler served as a captain in the 211th Engineers at Camp Meade.

In 1922 Mr. Fowler went into private practice at San Francisco, during which time he served as a consultant for the Corps of Engineers and later for the Public Works Administration on numerous dam construction project in the West. He was a member of the commission that reported on the failure of St. Francis Dam. From 1938 to 1941 he was consultant to the Department of Water and Power at Los Angeles.

Much of Mr. Fowler's time in recent years was spent in Washington in various capacities, including those of: director of the national drainage basin study of the National Resources Committee; chief of the civil engineering group of the Construction Division of the Quartermaster Corps, and chief consulting civil engineer in the Office of the Chief of Engineers.

Mr. Fowler served the American Society of Civil Engineers as president in 1941.

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A.S.C.E. inaugurates public relations bureau

Allen Wagner, former public relations director of the Minnesota Mining and Manufacturing Co., St. Paul, Minn., and a former Twin Cities newspaper man, has been named public relations assistant to William N. Carey, secretary and executive officer of the American Society of Civil Engineers.

The society said in a recent announcement that employment of a full-time public-relations man will aid in informing the public on engineers' work.

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

A Voice for All Engineers

Sir: The executive board of the Texas Society of Professional Engineers at its July 30 meeting reviewed the editorial, "A Voice for All Engineers", which appeared in *ENR*, March 8, vol. p. 307, together with the letters of comment which appeared in the May 31, issue, vol. p. 753. The board unanimously approved the action taken by S. D. Breeding, President of Travis Chapter, Texas Society of Professional Engineers, in sending the letter published in that issue.

The executive board was unanimous in its belief that the professional needs and professional problems of national scope can best be administered by the National Society of Professional Engineers, which is already operating and is steadily growing and gaining in usefulness.

ELGIN B. ROBERTSON
President, Texas Society of Professional Engineers

A Layman's View

Sir: Your recent letter was intended, of course, for my son, Richard A. Geis, Jr. who has been on various jobs ranging from Newfoundland to east and west North Africa for the past four years and is at present in Saudi Arabia.

I realize that your letter was not addressed to laymen, but during Dick's absence I have been an intertested reader of your magazine and have enjoyed its contents so much that I wish to have the privilege of complimenting you on a magazine which, while essentially for the construction industry, is interesting and instructive reading outside of your profession. It was only through reading your magazine that the realization came to me of the tremendous debt of gratitude the citizens of this country owe to the engineering and construction divisions.

Incidentally, I feel that too few words of commendation have been extended to the civilian employees of the United States Army Engineers who have served so well and so diligently and very often under terrific conditions.

RICHARD A. GEIS
Lawyer, Brooklyn, N. Y.

Dog on Suspension Bridge Again

Sir: Long ago someone illustrated the cumulative effect of impulses on suspended structures by telling about a dog trotting across a suspension bridge. It was a good story and it isn't dead yet. The San Francisco-Oakland Bay Bridge recently received a letter from a serious minded young lady who wrote:

> "I would like to know whether or not a dog is allowed to cross a cable bridge. We have had a discussion about the danger of making the bridge sway and feel that the only way to find out is to ask. I heard that a dog which attempted to cross either the Oakland Bay or Golden Gate Bridge, I am not sure which, was shot for this reason. Is that true?"

Some grain of truth underlies most of the popular notions about engineering principles. The difficulty is that when the grain of truth gets too widely separated from its fellows the associated misinformation dominates and like the man with seven bad companions, "the last state of that man is worse than the first."

K. T. ROBERTS,
San Francisco, Calif.

The Hankinson Formula

Sir: The article by F. C. Smith on the Hankinson formula (*ENR* July 12, 1945, vol. p. 50) and the recent publication of *National Design Specification for Stress-grade Lumber and its Fastenings* suggest a re-examination of the formula. The Hankinson formula was undoubtedly the best formula up to its time for estimating the bearing strength of wood at an angle to the grain. It does not seem to be generally recognized, however, that the formula was proposed as the result of tests on spruce for airplane construction, as Mr. Smith points out. When tests on other woods are examined, it is found that the discrepancy between values of n (bearing stress at angle Θ) obtained from the formula and those obtained in the tests may be large. A formula proposed by the writer (*ENR* Feb. 9, 1928, p. 243), of which Hankinson's formula is a special case, is more flexible:

$$n = \frac{PQ}{Q + (P - Q)\,(\sin^2\theta + a\cos^2\theta)\,\sin^2\theta},$$

where a is a parameter that may vary from 0 to 2. When $a = 1$, the formula becomes Hankinson's formula.

Good agreement with tests was found by taking the following values of a:

Cypress	0.05
Southern pine	0.35
Redwood	0.45
Chestnut	0.45
Douglas fir	1.55

If the formula is written in the form

$$n = \frac{PQ}{Q + (P - Q)\,K},$$

where

$$K = (\sin^2\Theta + a\cos^2\Theta)\,\sin^2\Theta,$$

it becomes easy to use, for K can be tabulated for Θ and a as arguments.

WM. R. OSGOOD
Materials Engineer
National Bureau of Standards
Washington, D. C.

Collective Bargaining

Sir: The Research and Engineering Professional Employees Association, of Whiting, Ind., and the Standard Oil Company (Indiana) signed a contract on March 12, 1945. The REPEA is the certified collective bargaining agent for nearly all of the non-supervisory technical professional employees at the Whiting Refinery. This organization was formed July 2, 1943, and was certified by the NLRB on February 29, 1944. About 90 percent of the engineers and chemists in the bargaining unit are members of the organization. The REPEA was the first independent organization composed solely of technical employees at the professional level to obtain NLRB certification. A second such organization, the Association of Prossional Engineering Personnel, at CA Victor in Camden, N. J., has cently been certified, and the Association of Industrial Scientists, at hell in Emeryville, Calif., has petitioned the NLRB for certification.

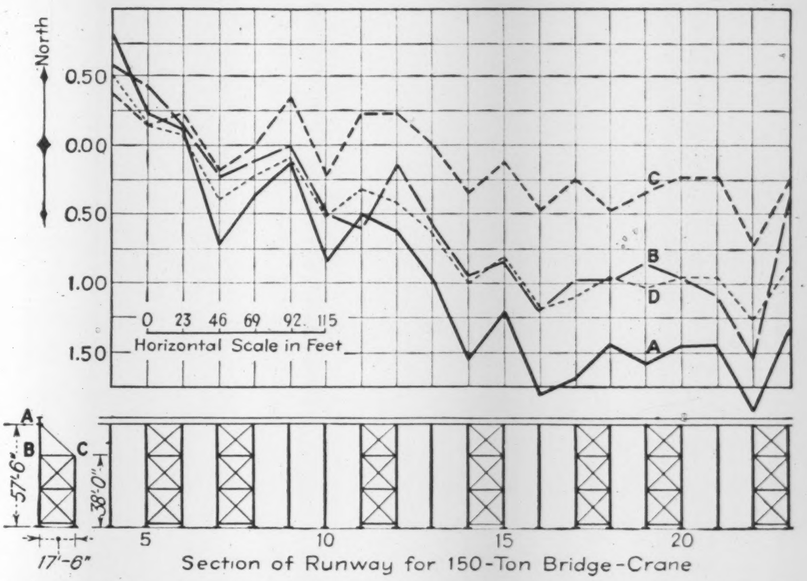
The chief feature of the contract, hich will be effective until March 1, 1946, is a well-defined procedure r handling questions involving salaries, hours and other conditions of mployment. This procedure culminates, if necessary, in arbitration y the U. S. Department of Labor. A friendly relationship exists between the company and the REPEA; he contract is evidence that his relationship will continue. Since ollective bargaining for technical mployees at the professional level is new development, much time and tudy by both the company and the REPEA were devoted to the preparation of this contract. During the year ince certification, numerous other atters in addition to the contract ave been the subject of discussions etween association and company representatives. Agreements reached on everal of these matters have been ncorporated in the contract. One uch item is a provision to encourage ttendance at national meetings or ommittee meetings of recognized echnical and professional societies. The company will grant leaves of absence with pay to each technical employee for a period up to six days per ear for attendance at such meetings.

PHILIP HILL
Chairman
REPEA Public Relations Committee
Whiting, Indiana

onventional Bracing Faulty

ir: Ned L. Ashton's letter (*ENR* ec. 14, 1944, vol. p. 741), entitled "Conventional Bracing Faulty," criticizes the defective methods of wind d sway bracing that are widely ed. In pointing out the weakest ots it applies itself to a much oader field than the article by Mr. eitzman (*ENR* Nov. 16, 1944, vol. 627), to which it is a reply. This iscussion brings to mind a case of nventional bracing that no doubt r. Ashton would condemn.

A runway 506 ft. long for a 150-ton idge crane has crane girders that e 48 in. deep, resting on 23 bents aped as shown in the attached etch and spaced 23 ft. on centers.



Deflections of crane girder bents 4 to 23 from a vertical through the base of each bent are shown as measured at points A, B and C.

The bents are numbered from south to north. At varying intervals, adjoining bents are tied together by light-angle diagonal bracing on lines B and C; also by two struts running full length in lines B and C, thus forming seven fully braced towers. All bents were supposed to be plumb at the time of erection, which took place in late summer.

In the following winter the deflections from the vertical through the base of each column were measured for points A, B and C of all bents except 1, 2 and 3. The latter are part of a heavily braced building at the south end of the runway. These measurements were taken on 17 different days. The temperature at times of observation was 18 deg. F. on the coldest and 66 deg. F. on the warmest day. As an example, the deflections taken February 2, with an average temperature of 31 deg. F. during time of measuring, are plotted on the accompanying chart.

Bent deflections recorded

The chart shows that south of bent 6 all bents lean north, while all bents north of 6 lean south. The deflections become larger the farther one goes away from bent 6, but this otherwise fairly continuous increase is interrupted, and in some places even reversed, at every braced pair of bents. The fact that the building at the south end is strongly braced explains why the reversal of the deflection takes place at bent 6 and not at half the length of the whole structure. The deflection of points B and C, compared with that of point A, is less than it should be considering the difference in height above the column base, evidently because the light longitudinal struts at points B and C could not exert the same pull as the very heavy crane girders at points A.

Line D in the diagram indicates the place where lines B and C should be theoretically. Wherever line B deviates from line D, it indicates that the main column is no longer straight; and where line C deviates from line D, it indicates that the whole bent is warped out of the original plane of the two columns. All this indicates deformations and consequently stresses that can be blamed at least partly on the conventional bracing here provided. Though computations show that stresses in all main members are within safe limits, they point out that stresses in tension diagonals near the north end of the runway are extremely high, while counter-diagonals are slack.

Mr. Ashton will no doubt agree that this design would be much improved if an expansion joint were provided near bent 6 as well as heavy diagonal bracing between bents 14 and 15, at the same time omitting all present diagonal bracing except in the building at the south end.

WALTER ROWLAND
Petersburg, Va.

EDITORIALS

VOLUME 135 NUMBER 20

November 15, 1945

Of What Use?

MANY OF THE THINGS that were done with wood and wood products within the closely guarded U. S. Forest Products Laboratory at Madison during the war were made public recently, as recounted elsewhere in this issue. Few of the new products appear to have great significance to our readers except possibly in the architectural field, so it will not be surprising if question arises as to why space is devoted to them. The reason lies in a belief that civil engineering is not static, and that wood as a construction material is so versatile that new forms may open up new avenues of use. A product that today appears to have application only in an airplane or in a container may turn up tomorrow as a useful device on a construction job as the result of the ingenuity of some unorthodox young engineer. Or the non-applicable product may stimulate thinking along lines that will produce one that can be utilized. In either case construction stands to gain. New knowledge is always worthwhile, no matter from what field it derives.

A Significant Treaty

RATIFICATIONS of the treaty between this country and Mexico relating to the waters of the three international streams, the Rio Grande, Tijuana and Colorado were exchanged in Washington last week, thus bringing to a close negotiations that have been carried on intermittently for nearly 20 years. This treaty is one of unusual significance to engineers. It was largely written by them, they played an important part in the negotiations, and they will be responsible for its administration. Further, a large amount of construction is called for within the next few years. But the most significant part of the treaty is its fixing of an upper limit on the waters of the Colorado that may be claimed by Mexico under the theory of prior appropriation that is applied to the waters of all western rivers in this country. That upper limit was actively opposed—again by engineers—as being too high, but our Senate accepted the findings of the engineers who negotiated the treaty. As it will be many years before delivery of that much water to Mexico will deprive anyone of water north of the border, it appears logical to act now rather than wait until the fixing of any *amount* would deprive some users either north or south of the border of water *actually needed* to irrigate their land. Today any shortage is highly theoretical; ten or twenty years hence it might be very real.

Continuity Analysis

AMONG THE DISADVANTAGES of conventional methods of analyzing continuous structures which are mentioned most often, are the necessity for solving simultaneous equations or of working toward convergence by successive approximations; the waste of time in computing unnecessary terms, such as fixed points, inflection points and unneeded angular rotations; and the inefficiency of plotting influence lines for static loads or of repeating calculations for various positions of moving loads. A method that attempts to avoid these difficulties is presented in the current articles on continuity analysis (*ENR* Nov. 1 and 15), and as the author points out it was developed by extracting the best practices from methods commonly used and modifying them as his experience dictated. For example, the concept of moment distribution, which has been so popular during the last decade, has been retained, but a solution is obtained in a single cycle, instead of by successive approximations. Also by utilizing simple concepts and permitting the designer to visualize the action of the structure under load, the method is claimed to apply to members of variable section with no more difficulty than it does to prismatic members. It is also said to be adaptable to short-cut procedures, an important characteristic when speed and economy are required. As a method planned to aid in greater ease and facility in designing continuous structures it is worthy of careful study and trial.

France Begins Again

THE OUTCOME of the recent French elections has a significance that American engineers, whose respect for French engineering accomplishments and friendliness toward French engineers are traditional, should not miss. It is that the forces whose ideas the electorate accepted are pledged to dynamic modernization of government, industry and agriculture as against blind adherence to old-fashioned methods. And the fact that these orces carry such Leftist labels as Socialist, Popular Republican and Communist should not be llowed to cloud the significance of their plans.

The effect of such a change in mental climate n French engineering should be profound, for ven without it the engineers of France have been mong the best in the world. In both reinforced oncrete and welded steel construction, for example, their contributions have excited world wide dmiration and emulation. In bridge design and rection and in river and harbor development they ave set precedents that we and other nations have een glad to follow. Their progressiveness under nefficient and unstable government has been phe- omenal. And the governmental machinery of he Third Republic was plagued with both of these haracteristics throughout all of its seventy years f existence; in the twenty-one years between the irst and second World Wars, France had forty- ive administrations presided over by twenty dif- erent premiers, so that inefficiency and occasional ncompetence were almost unavoidable. While it s not surprising that this type of setup was dis- arded, it is encouraging that the French people ad both the courage and the balanced judgment o do it through the democratic procedures that are heir birthright.

This, too, augurs well for French engineering, or scientific advancement flowers best where it is ree. A strong and productive France is essen- ial to the well-being of Europe and the world, but o be strong she must complete a Herculean task f construction in the next few years. A million nd a half ruined buildings and hundreds of ridges must be rebuilt. Her transportation sys- em and her industrial plant must be repaired. And her housing and sanitation facilities must be odernized. Short of manpower and in need of peed, her work will require more mechanization han ever before, and it will require engineering nd administration of a high order. All these the French engineer and construction man have the apacity to provide if the proper governmental and ocial environment is available.

Because she has taken the first step so courage- usly, France deserves the help and encouragement f the whole world in the next seven months as she truggles with the writing of a new constitution. If it is successful, France may readily surpass the technological achievements of her previous golden age in the 18th Century, when such great engineers as Vauban and Perronet were given free rein to exercise their talents. If the outcome is failure, we, as well as France, will be the loser.

Public Works—Now or Later?

EACH DAY brings mounting evidence that curtailment of much public-works construction is going to be necessary during the reconversion period. It may not be easy to accept this philosophy—coming as a complete reversal of thinking prior to V-J Day—but the facts are that we are faced with more construction demand than we have the present capacity to provide. And if public-works construction is to serve as a balance wheel for stabilization of the construction industry, then it is this type of activity that should be postponed until construction demand is reasonably satisfied.

Regardless of the pros and cons of this principle, it is a reality that public-works construction already is being stymied. Bids taken on job after job have been much higher in cost than anticipated, and these bids generally have been rejected. Because the need persists for these public works, however, there exists the temptation to ask for new bids and to let contracts at prevailing high prices. And yet this practice, if too generally followed, may well push prices even higher, with the ultimate result that both public and private construction volume will suffer. The alternative is to forego for another year or more such public work as is not absolutely necessary.

It will probably require all of that time for the construction industry to reconvert itself to meet the demands placed upon it, demands that seem destined to exceed those of all previous times. Moreover, the industry faces the same problems that beset every segment of our economic life, namely uncertainties concerning materials and labor, and these slow up the process of conversion.

Elsewhere in this issue is an appraisal of the outlook for public works presented at a meeting of the American Public Works Association held in Chicago last week. The emphasis placed by a number of speakers on the desirability of postponing such construction may be taken as further evidence of the necessity for such a course.

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Tests on Creosoted Laminated Stringers

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Contents in Brief*—To determine the effect of pressure creosoting on a cured phenolic glue line and the strength characteristics of creosoted, laminated, railroad bridge timbers, 18 laminated Douglas fir beams were tested. It was apparent that pressure creosoting subsequent to laminating and curing had no deleterious effect upon the strength of beams laminated with low-temperature phenolic resin glue, nor upon the bond strength and durability of the phenolic glues used. However it was found that incising, employed prior to pressure treatment to secure deeper and more uniform penetration of the preservative, caused a definite reduction in the bending strength of dry laminated beams.*

Recent development of reliable waterproof glues and laminating techniques and the manifest advantages of laminated wood construction has spurred interest in the strength properties of such timbers and in their treatability with preservatives to materially increase service life under severe exposure. To answer the queries of railroad engineers interested in designing with laminated timber, the series of tests reported in this article were undertaken.

A total of 18 Douglas fir beams were fabricated and tested. They were laminated in accordance with the specification of the Bureau of Ships, U. S. Navy, the only authoritative specification available that covers laminating of Douglas fir with waterproof, phenolic-resin type glues. The dimensions of these test beams were approximately equivalent to those generally employed in railroad stringer design.

Tests on Douglas fir timbers

Beams 1 to 9, inclusive, were laminated from commercial run, nominal 1 x 8 D & Better, kiln-dried Douglas fir, and the laminations were scarfed when necessary to splice for length by employing a 1 in 12-slope plain scarf joint that was machine cut. Each of the beams in this group measured about 8 x 18 in. by 16 ft. Beams 10 to 18, inclusive, were laminated from commercial run, kiln-dried, Select Structural dimension (2-in.) Douglas fir. The laminations also were scarfed for length, when necessary, using a 1 in 12 plain scarf. The beams in this group each measured about 8 x 16 in. by 16 ft. when finished.

The stock for the individual beams was sorted so that each beam was composed of all flat grain or all vertical grain material in the laminations. In addition, the moisture content of each lamination was determined with an electric moisture meter, and a maximum variation of 3 percent was permitted between the wettest and the driest lamination in any one beam.

Penacolite G-1131, a room-temperature resorcinol-resin glue was employed for scarf gluing, and the

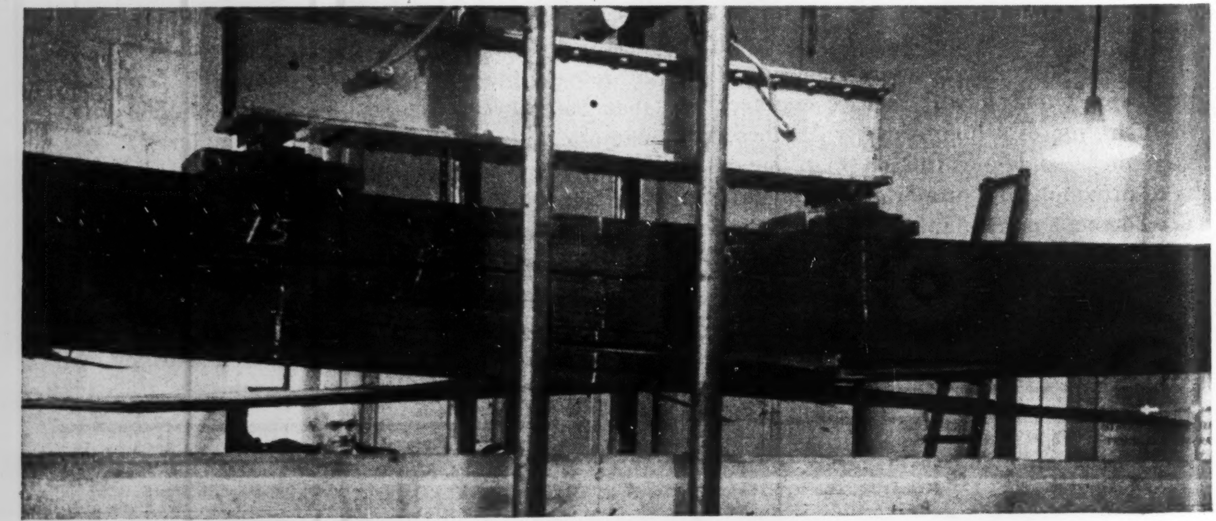


Fig. 1. Bending tests on laminated timber stringers indicated that pressure creosoting had no apparent effect on strength.

joints were glued prior to the laminating operation. The laminating was done with Cascophen LT-67, a low-temperature phenol-formaldehyde type of resin glue. The beams were cured while under clamp pressure of 150 psi. in a special curing chamber in which the temperature and humidity were instrument-controlled. A dry bulb temperature of 160 deg. F. was held for approximately 20 hr. to effect a cure of 140 deg. F., as maintained at the innermost glue line of each beam for at least 10 hr.

Three beams in each group of nine were tested without any processing subsequent to the laminating operation; three beams in each group were incised, but not creosoted, after fabrication; and the remaining three beams in each group were first incised and then creosoted with an 8-lb. empty-cell treatment as ordinarily applied to solid, seasoned Douglas fir timbers.

Incising aids penetration

Incising is generally employed prior to pressure treatment of Douglas fir ties, poles or timbers as an aid in securing deeper and more uniform penetration of creosote by exposing the ends of the wood cells to the preservative. Douglas fir is regarded as a wood that is moderately hard to treat, and incising, particularly when green material is artificially seasoned, is usually advantageous. Incisions were spaced $1\frac{5}{16}$ in. apart in the direction of their length, as illustrated in Fig. 2, with rows offset to avoid a decrease in horizontal shear resistance. Made with an oyster-shell point knife, the incisions were $\frac{5}{8}$ in. long, $\frac{1}{8}$ in. wide at the surface and $\frac{5}{8}$ in. deep.

No delamination from treatment

The preservative treatment consisted of a 4-hr. period of heating in oil at 190 deg. F., a 3-hr. pressure period (100 psi.) at 190 deg. F., a 1-hr. expansion-bath or clean-up under vacuum at 190 deg. F., and a 2-hr. final vacuum after the oil had been drained from the treating cylinder. Treating records showed absorptions ranging from 8 to 10 lb. of creosote per cubic foot of wood. Test beams given the pressure creosote treatment after fabrication were carefully examined, and no delamination or deterioration of the glue bond was evident. Sections of the creosoted beams cut out after testing have been subjected to weather exposure for one year and do not show any evidence of delamination.

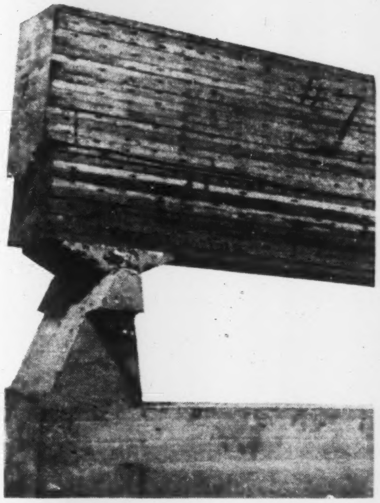


Fig. 2. Beam 7 failed in shear. Note that the shear "plane" crosses laminations at random. Rows of incisions were staggered to avoid a decrease in horizontal shear resistance.

In making the tests, a universal testing machine with an 18-ft. extended platform was used. All beams were tested in accordance with the specifications of the American Society for Testing Materials, employing third-point loading on a 15-ft. span. Deflections were read in units of 0.01 in. at load increments of 4,000 lb. Stress-strain charts were prepared from the data for each test, and strength values were computed from recognized formulas.

Results of the beam tests together with other pertinent information are summarized in the accompanying table. It is clear that the beams laminated from Select Structural stock were superior in strength properties to those laminated from the D & Better stock. This latter grade is not a stress grade, although it is frequently preferred for laminated boat parts and other applications where surface blemishes are considered to be defects. D & Better lumber is frequently fine grained, soft, and low in density, and cannot be expected to exhibit the higher strength qualities of a structural grade. Spotty grain deviations in some of this stock contributed materially to tension failures, while a shake and two large pitch pockets in one lamination caused an early shear failure in Beam 8, which was, however, kept under load until a tension failure was produced.

Bending strength reduced

The influence of incising upon the strength of the laminated beams of the dimensions employed in these tests was quite evident. The reduction in bending strength of laminated beams of the sizes employed, occasioned by incising alone, averaged about 10 percent for the beams laminated from 1-in. material and nearly 20 percent for the beams laminated from 2-in. stock. The beams that were incised and then creosoted did not show any further significant reductions when tested,

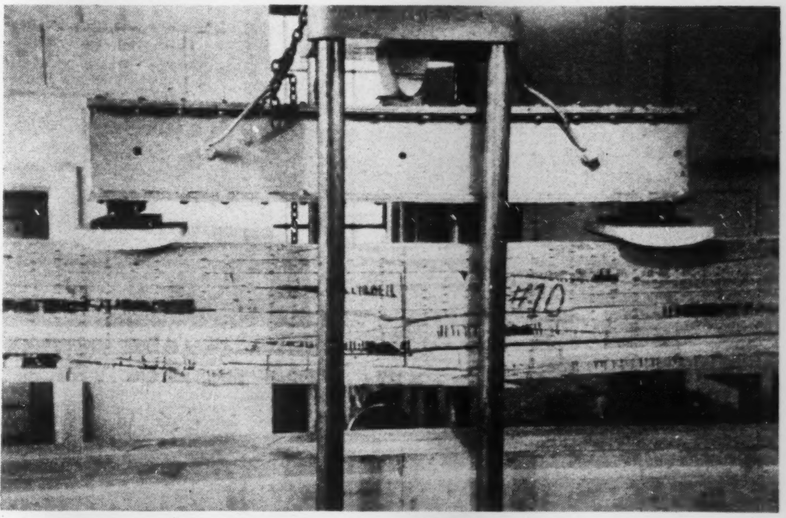


Fig. 3. After complete tension failure of Beam 10, there were no failures in any glue lines. Dark spots are glue squeeze-outs. Note the 1 in 12-slope plain scarf joints used in splicing laminations for length.

BENDING TEST RESULTS ON LAMINATED RAILROAD STRINGERS

Beam No.	Treatment	Modulus of rupture (psi.)	Maximum shear stress (psi.)	Modulus of elasticity (psi.)	Type of ultimate failure
Laminated from nominal 1-in., net 3/4-in. D. & Better Douglas Fir					
1	Incised & Creosoted	6,802	505	1,705,000	Tension
2	" "	6,336	470	1,768,000	Tension
3	" "	7,506	557	1,719,000	Tension
Average	" "	6,881	511	1,730,000	
4[1]	None	7,989	586	1,728,000	None
5	"	7,489	551	1,926,000	Tension & shear
6	"	7,745	569	1,742,000	Tension & shear
Average		7,741	569	1,799,000	
7	Incised Only	7,021	518	1,750,000	Shear
8	" "	7,607	339[2]	1,780,000	Shear
9	" "	6,391	471	1,761,000	Tension
Average		7,006	443	1,764,000	
Laminated from nominal 2-in., net 1 5/8-in. Select Structural Douglas Fir					
10	Incised Only	7,014	432	1,753,000	Tension
11	" "	8,087	508	1,804,000	Shear
12	" "	7,461	466	1,943,000	Tension
Average		7,521	469	1,833,000	
13	Incised & Creosoted	8,747	549	2,012,000	Tension
14	" "	7,346	462	1,858,000	Shear
15	" "	7,895	498	1,832,000	Tension
Average		7,996	503	1,901,000	
16	None	9,305	581	1,881,000	Tension
17	"	9,537	594	2,030,000	Shear
18	"	9,439	588	2,122,000	Tension
Average		9,427	588	2,011,000	

NOTES: [1] The calculated strength factors for Beam 4 are based on a load of 100,000 lb. (machine capacity), although the beam had not yet failed. These values are, therefore, below the actual stresses for this beam. It is presumed that failure by horizontal shear was imminent.

[2] Beam 8 failed in shear at an abnormally low load. Examination indicated that failure resulted from shake and large pitch pockets in one lamination that were not detected at the time of fabrication. Subsequent to failure by shear, this beam was kept under static load until it failed in tension. The bending stress was computed using the original beam depth.

Moisture content determinations made on core sections, showed that all moisture contents were within the range of 11–14 percent at the time of test.

which indicates that the creosoting treatment itself did not significantly affect the strength of the laminated timbers in these tests.

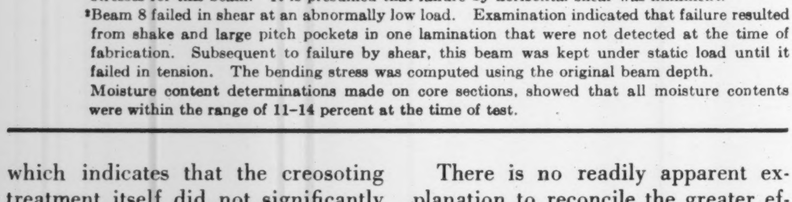


Fig. 4. At complete tension failure, Beam 13, 8 by 16 in. on 15-ft. span, incised and creosoted, had a modulus of rupture of 8,747 psi., shear stress of 549 psi. and modulus of elasticity of 2,012,000 psi.

There is no readily apparent explanation to reconcile the greater effect of incising upon the beams laminated with 2-in. stock. It was obvious from visual examination that incising in many cases caused more or less minor splitting and splintering on the surface of these dry beams, a type of defect that would not occur in incising green material. It is possible that these splits and checks penetrated in some cases through an entire lamination and, therefore, would affect the beams of 2-in. laminae to a greater extent than those of 1-in. material.

Tension failures predominated

In reviewing the data as listed in the table, it may be noted that tension failures predominated but that there were a considerable number of shear failures. The individual stress values for each beam should be correlated with the type of ultimate failure produced since some values are not ultimate, as in cases where shear values are listed for beams that failed in tension. One of the test beams showed a compression failure prior to the ultimate fracture.

Shear failures were not confined to single laminations but crossed glue lines at random, indicating that the glue-bond shear value was higher than that of the wood itself. This is clearly illustrated in Fig. 2. During these tests no glue failures were noted, and in all cases that portion of a failure adjacent to or paralleling a glue line pulled more than 75-percent wood fiber from one or the other of the bonding surfaces as measured over the area of failure. This is considered an adequate measure of a reliable glue bond.

Working stresses

The calculated strength values derived from this series of tests show that the beams laminated from Select Structural dimension lumber are equivalent to or better than solid beams of the same grade in strength qualities. Those beams laminated from the clear 1-in. material are also in general equivalent to a 1,600-f grade (1,600-psi. bending stress) of Douglas fir, but the grade rule for this class of stock does not offer any protection from low-strength material and the results can not, therefore, be regarded as indicative of a general run of material in the clear grades.

Laminated beams offer possibilities of increased stress allowances as compared to solid timbers of equal grade under certain conditions of service. Since laminated beams are thoroughly and evenly dried throughout, they will be stronger and stiffer than heavy solid beams. No serious hidden defects, such as may occur in solid timbers, will be present in laminated timbers as each lamination can be carefully examined at the time of fabrication.

It must be borne in mind that the strength increment resulting from the dry condition of laminated beams does not hold good for exterior unprotected service, since the critical portions of the beams are the first to be wetted by precipitation and atmospheric moisture. Laminated beams are not subject to the severe checking and twisting frequently observed in solid beams as they dry in service.

Although the tests reported herein are insufficient for conclusive evidence, the following summary is indicative of the strength properties of the laminated beams tested.

1. Standard pressure creosoting treatment apparently does not affect a properly-cured resorcinol or low-temperature phenolic resin glue bond on Douglas fir.

2. Incising caused a definite and significant reduction in the bending strength of these dry laminated beams. This reduction varied between 10 and 20 percent in this series of tests but would, undoubtedly, be affected by beam size, type of knives and incising pattern employed.

3. Pressure creosoting treatment did not seem to affect the strength of the laminated beams when the incising effect is taken into consideration.

4. Beams laminated with stress graded lumber, are equivalent or superior to solid beams of the same grade in bending strength, shear and stiffness.

Fabrication and testing of the beams were carried out in connection with a pilot plant operation of Timber Structures, Inc., at Seattle, Washington. This operation was sponsored by the Office of Production Research and Development of the War Production Board as a direct contribution to the war effort. Incising and creosoting were accomplished through the cooperation of the West Coast Wood Preserving Co., Seattle. The tests were made in the laboratory of the College of Forestry, University of Washington, with the cooperation and assistance of Prof. Bror L. Grondal of the Department of Forest Products.

Semi-Circular Spillway in Action

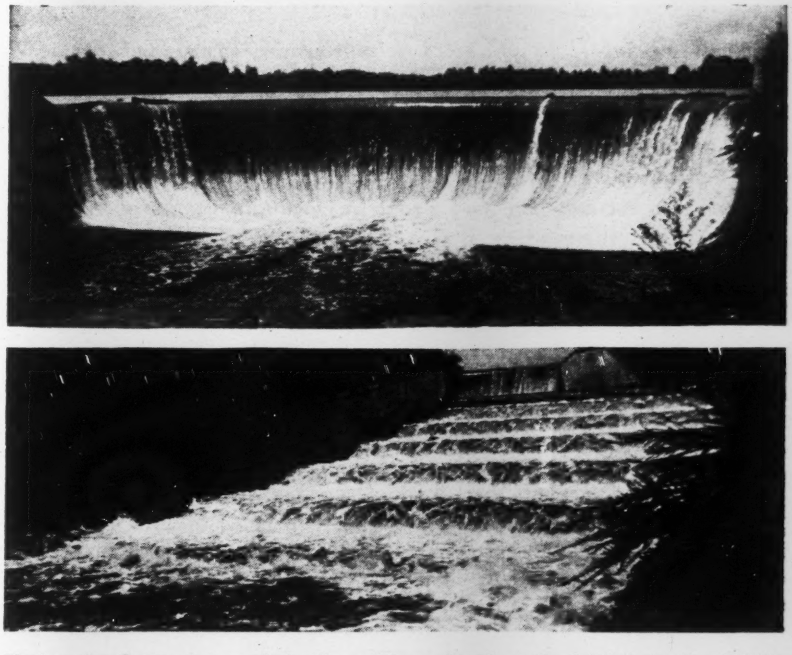
Completion of clearing operations in the extra area to be flooded following construction of an earthfill dam at Lake Burnt Mills (*ENR* June 17, 1943, vol. p. 898) recently permitted filling of the additional capacity of the reservoir, which supplies Norfolk, Va., with part of its water supply. First water flowing over the bow-shaped spillway weir is shown in the accompanying illustrations.

The semi-circular concrete spillway, built on a radius of 55 ft. with crest 19 ft. above the outlet channel floor, is situated a short distance to one side of the original stream channel at the 40-ft. embankment location. Flow over the spillway collects in a pool at the center of the curve, passes through a hydraulic jump and is returned to the tailwater by a curved concrete channel terminating in a series of broad steps that dissipate remaining energy.

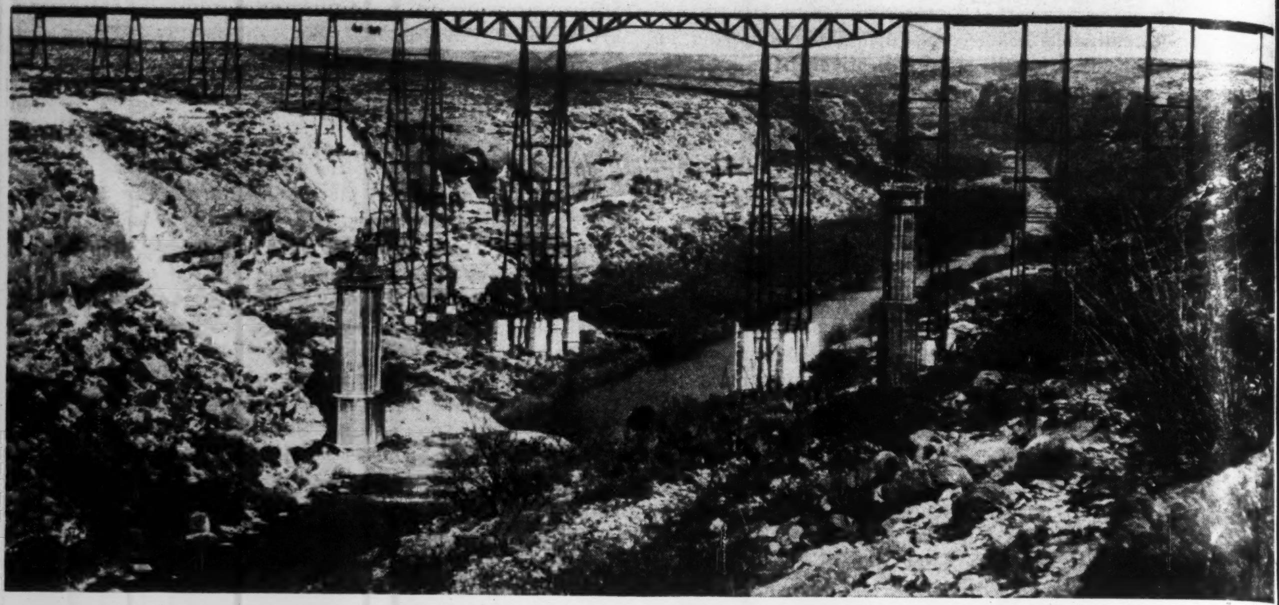
Such a structure was made possible by the fact that the dam is underlain by a mixture of sand, silt and fine shells (known locally as "blue marl") so thoroughly compacted that it is practically impervious to percolating water and is not eroded by water flowing over it. The spillway base was designed to rest on this stratum, with a cutoff wall extending down into it. Also, pockets 6 to 10 ft. deep below the floor of the outlet channel were excavated into the impervious layer and filled with concrete cast integrally with the floor of the spillway channel.

Top of the embankment is 5 ft. above spillway crest. Using this depth for overflow, city engineers estimate the spillway capacity to be about 8,000 sec.-ft., or slightly more than 300 sec.-ft. per sq. mi. for the 25-sq. mi. drainage area. The enlarged reservoir holds 3,400,000,000 gal.

Design of the dam and spillway was by the Norfolk municipal department of public works; construction was by Liberty Contracting Co., Richmond, Va.



First water flows over semi-circular spillway (top) at Norfolk's Lake Burnt Mills reservoir. Hydraulic jump can be clearly seen in pool at foot with 8-in. depth on crest. Lower picture shows broad-stepped, curved channel for dissipating remaining energy before reaching tailwater.



Alongside spectacular old Pecos River viaduct, construction of tall piers for replacement bridge is well advanced.

Pecos Gorge in Texas Spanned By New Railroad Bridge

Harry J. Engel

Staff Member, Modjeski and Masters, Harrisburg, Pa.

Contents in Brief—*Built during the war to replace a famous and spectacular, but light and inadequate, viaduct over the gorge of the Pecos River in Texas, a new bridge of the Southern Pacific is designed for E72 live loads plus earthquake and wind forces. A continuous cantilever deck structure, its hollow concrete piers rise to 275 ft. and were built with slip forms. Provisions were made in the superstructure design to facilitate cantilever erection.*

THE NEW PECOS RIVER railway bridge in southern Texas, a vitally important link between New Orleans and Los Angeles, replaces the original Pecos River Bridge built in 1891 and recognized for many years as the world's highest railway viaduct. Spectacular like its predecessor because it spans a deep rocky gorge, the new bridge is much more massive, being designed for E72 live loads as well as for earthquake forces and substantial wind loads. It is of continuous deck cantilever type, with a 375-ft. main span, and is carried by hollow concrete piers, the tallest of which rises 275 ft. from the bottom of the gorge. These piers were built with slip forms, concrete being delivered by cableway, and the superstructure erection was by cantilever methods aided by jacking over the piers.

The original viaduct was a single track bridge built principally of wrought iron, and supported on high four-leg wrought iron and steel towers. Strengthened in 1909-10 by the addition of center columns and trusses of medium steel, the viaduct was again remodeled in 1929 by having various details reinforced as necessary to bring the loading capacity up to Cooper's E60 with operating speeds restricted to twelve miles per hour. But even under these conditions of operation it was necessary to keep the structure under close observation and continued maintenance. The towers required frequent plumbing by adjustment of diagonal bracing rods, and fatigue cracks developed from time to time in bracing details.

Although the company managed to operate satisfactorily and meet the demands of traffic in the prewar years (even though it was not possible to use the heavier equipment employed on other sections of the line in regular service over the viaduct) the great increase in traffic due to the war changed the picture completely. It soon became evident that the volume and frequency of movements were such as to preclude the practicability of strengthening and repairing the old viaduct under traffic, and it was decided to replace it with a modern structure. An application for materials was made through the Office of Defense Transportation on Feb. 17, 1943, and an AA-3 priority was granted by the War Production Board on June 19, following. Design studies for a new bridge had been begun late in 1942, and as a result it was possible to start construction soon after approval by the WPB, namely in August, 1943. (The project is only now being described because hitherto it has been subject to War Department censorship—Editor).

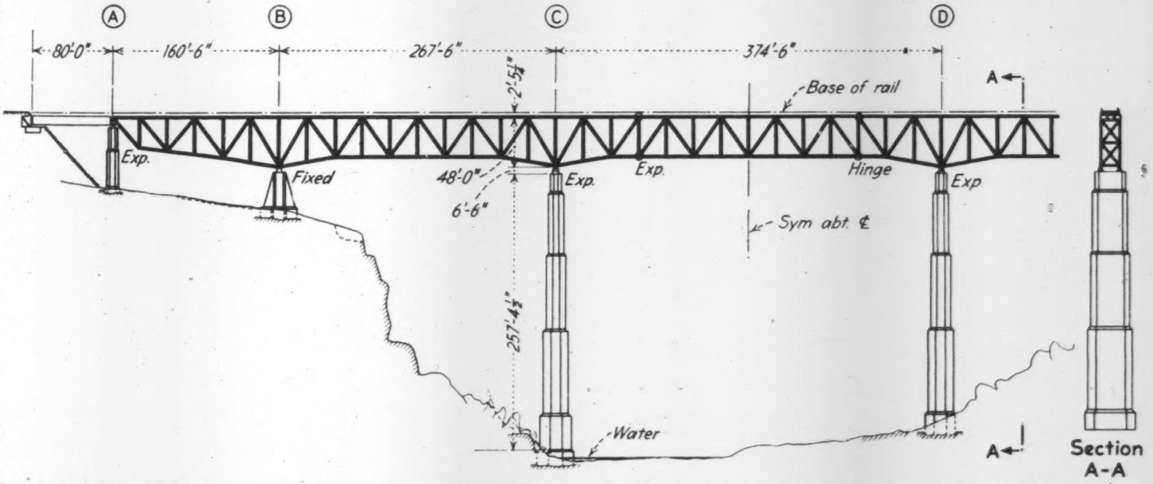
General conception of new bridge

A single-track, deck structure, the new bridge crosses the Pecos River canyon on a line about 440 ft. downstream from the original viaduct, at a point in the gorge that is uniquely favorable to bridge construction. The rock cliffs at the new site are sound and about 770 ft. apart, while the gorge is 322 ft. deep from base of rail to ordinary water level in the shallow stream. Limestone rock is the founding material for all piers of the main bridge.

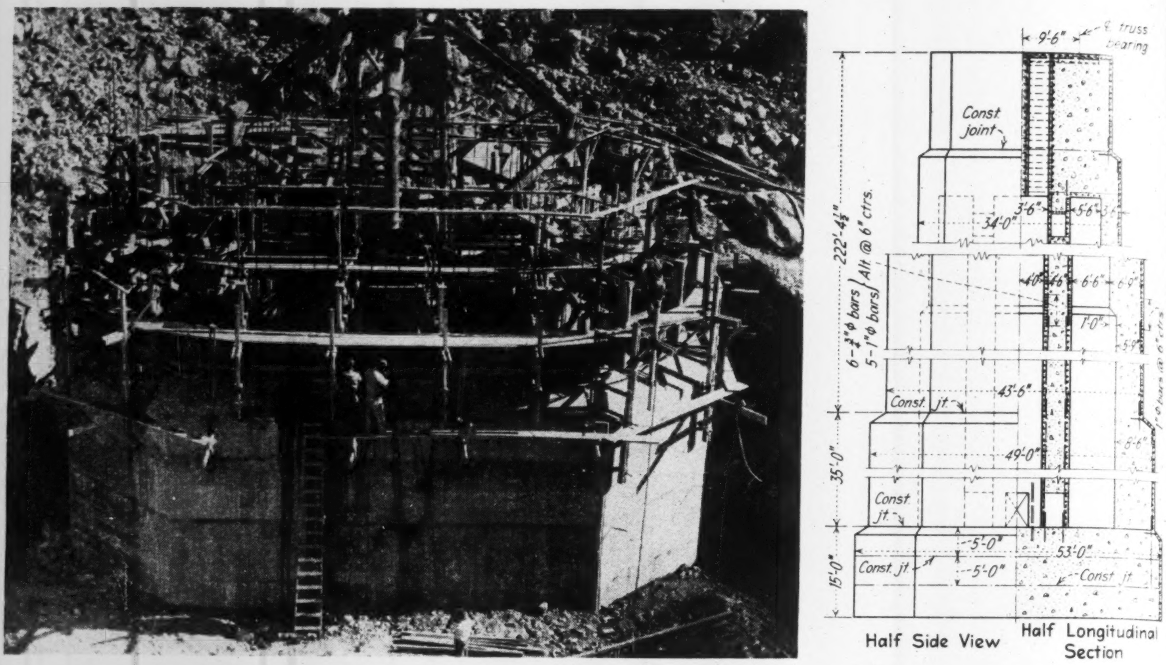
The new structure is of continuous-cantilever truss type, with its design dictated by considerations of topography, erection, earthquake and train forces and wartime necessity for the most efficient use of structural steel. Of medium carbon steel, on reinforced concrete piers, the bridge was designed for E72 live loads, with unit stresses based upon 18,000 psi. for carbon steel in tension and bending.

The design was selected from among twelve economic studies on preliminary designs of various types of bridges, including a 600-ft. steel arch with flanking simple truss spans, a multiple cantilever of 363-ft. main span, a series of 228-ft. simple spans, a cantilever and girder structure on steel towers, a similar design on reinforced concrete bent towers, and

Long span cableway was used by substructure contractor to deliver concrete to the piers in a 2-cu. yd. bucket.



New railway bridge over Pecos River gorge in Texas is of continuous-cantilever type on unusually tall concrete piers. Designed for E72 live loads, wind and earthquake, it is a heavy structure compared to its predecessor.



Piers of Pecos River bridge, of hollow concrete type (right), were designed with straight sides to permit ready use of slip form method of construction (left).

various arrangements of cantilever and continuous cantilever designs on concrete piers. Of these various designs, the least amount of steelwork, (2,700 tons) the greatest economy under wartime conditions, and the most satisfactory structure was obtained with the continuous cantilever type. In addition, the great height of the canyon demanded a type of design suitable for cantilever erection.

Short piers take earthquake forces

In the adopted continuous-cantilever design, a longitudinal earthquake force of 0.1*g* and the tractive and braking forces of the train are taken by the short piers B and E on the cliff tops, which have fixed shoes each of which is anchored into the pier with twelve 1¾-in. dia. bolts embedded 10 ft. These are gravity type piers for which no tension exists on the foundation under any combination of the design loadings.

The tall piers in the gorge, one of which is 275 ft. high from its rock foundations, have expansion rollers on their tops and, therefore, do not participate in longitudinal forces from the superstructure or braking forces from the live load. Under longitudinal 0.1g earthquake, and longitudinal 15 psf. wind force (wind blowing across the gorge) the resultant force on the rock at the foundation of each of the high piers lies safely within the pier base with maximum edge pressures in the concrete of less than 450 psi.

Under transverse 0.1*g* earthquake acting on both superstructure and piers, and with a 30 psf. wind blowing across the structure, the resultant edge pressure in the concrete is 400 psi. Under the specified 50 psf. wind force transverse to the bridge on the projected area of both trusses, no tension is created on the pier base. The ordinary dead plus live load pressure on each pier base is only 9.6 tons per sq. ft. During construction of each pier from four to nine exploratory holes were drilled in the rock to a depth of 20 to 25 ft. below founding level, verifying the soundness of the rock under these pressures.

The superstructure was designed for continuity over piers B and E to accommodate the structure to the scheme of erecting steelwork from the two sides of the gorge to closure at the center of the suspended span. This scheme of erection was particularly feasible because of nearness of the new alignment to the old, and the early placement of the rock fill approaches that made it possible for materials to be brought directly to the ends of the structure on each side of the gorge.

The basic scheme contemplated in the design consisted of the erection of spans AB and EF on falsework; the cantilever erection of spans BC and DE without falsework to landing on the high piers, aided by eight 2¼-in. dia. tie rods embedded 32 ft. into Piers A and F to provide anchorage; and finally the cantilever erection of the 374-ft. 6-in. central span to closure at the center, provision for jacking to closure being made in the top and bottom chords at the ends of the 214-ft. suspended span. The design provided that the suspended span was then to be swung free by release of the jacks, after which the top chord members over piers B and E were to be freed and the connections reamed with no stress. Thus, the trusses over Piers B and E were theoretically hinged when the bridge was subjected only to erection dead load, and are continuous under the additional dead load of the finished deck, and under live load, impact and wind forces.

A 77½-ft. girder span completes the steelwork on each end, resting on an abutment supported on a high rock fill.

Superstructure details

The main trusses are 19 ft. center to center, a dimension established as the result of thorough investigation of overturning forces at the roller shoes on the tops of the high piers. The continuous truss groups are each supported on two reactions at the same level, and a raised reaction at the bridge end, an arrangement that has been found to be inherently stable against overturning. The continuous-cantilever type of structure is, moreover, especially resistant to sidewise deflection under transverse forces, a factor favoring the 19-ft. truss spacing which in turn results in a compact bracing system. The top laterals consist of split beams so framed into the plane of the top flanges of the rolled beam stringers as to participate in tractive forces. Wind tongues in the bottom chord transfer the lateral forces from the suspended span to the cantilever arms of the main span.

The deck has a wrought iron sheet covering the ties to prevent corrosion of the structure from brine drip and to provide fire protection for the ties. As incidental details of this deck protection, the rail tie plates are on special insulation pads, and an electrical stop is provided between the two rails by means of a wood separation strip along the center of the deck, thus providing broken rail protection. Checkered plate walkways and railings are provided along each side, and an inspection walk runs beneath the floor, which is accessible from ladders at end piers A and F. Ladders from the deck also provide access to the tops of the high piers, and protective railings are used on all pier tops.

The expansion shoes at end piers A and F are of the link type designed as such to resist erection uplift at these end anchorages. Auxiliary wind anchorages are also provided on the bridge centerline at these piers.

Substructure design

The two high piers C and D are of particular interest, for they are made hollow with diaphragm walls to achieve lightness under the effect of earthquake forces, and to facilitate the curing of the concrete. Moreover, like the end piers A and F, they were designed with vertical sides, narrowed in occasional steps, so as to save critical form lumber. Octagonal pier ends were chosen to conform architecturally to the rugged character of the rock cliffs of the site.

Reinforcing at the tapering transition sections in pier width was designed for the octagonal ends as though each such portion was a segment of a dome, with special bands of steel at the bottom of the transition to take the resulting tension around the pier ends and the bending forces created in the straight portion of outside walls between the vertical diaphragms. Special bands of reinforcing in the diaphragm walls resist the tensile forces at the bottom of each such transition section. Access doors are built into the tops and bottoms of each high pier, and rectangular openings in the top and bottom of each diaphragm wall permit access to all wells. The substructure contains 15,500 cu. yd. of concrete.

Work on the substructure contract, held by Brown & Root, Inc., Austin, Tex., was started in late August, 1943, with the construction of a camp for housing and boarding personnel. Camp provisions were trucked from Del Rio, and water was supplied by the railroad company from its elevated tanks at the bridge site.

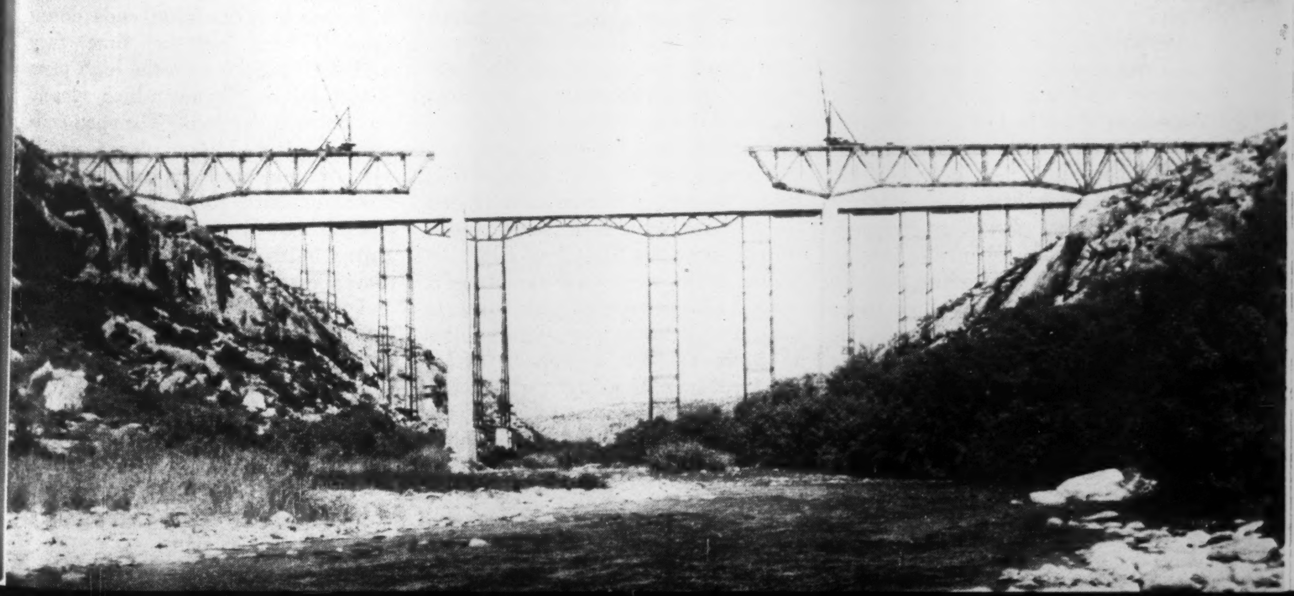
Loose, hanging rock was first removed from the faces of the canyon walls to prevent possible injury to workmen. This work and excavation for the pier footings were performed almost entirely by hand labor aided where possible by blasting. Adequate keys for all piers were excavated into the rock. Only at high pier C at the west edge of the river was protection necessary for the excavation work. Here the stream flow was diverted by the construction of an arc of dike on the river side of the pier, so that concreting could be carried on in the dry.

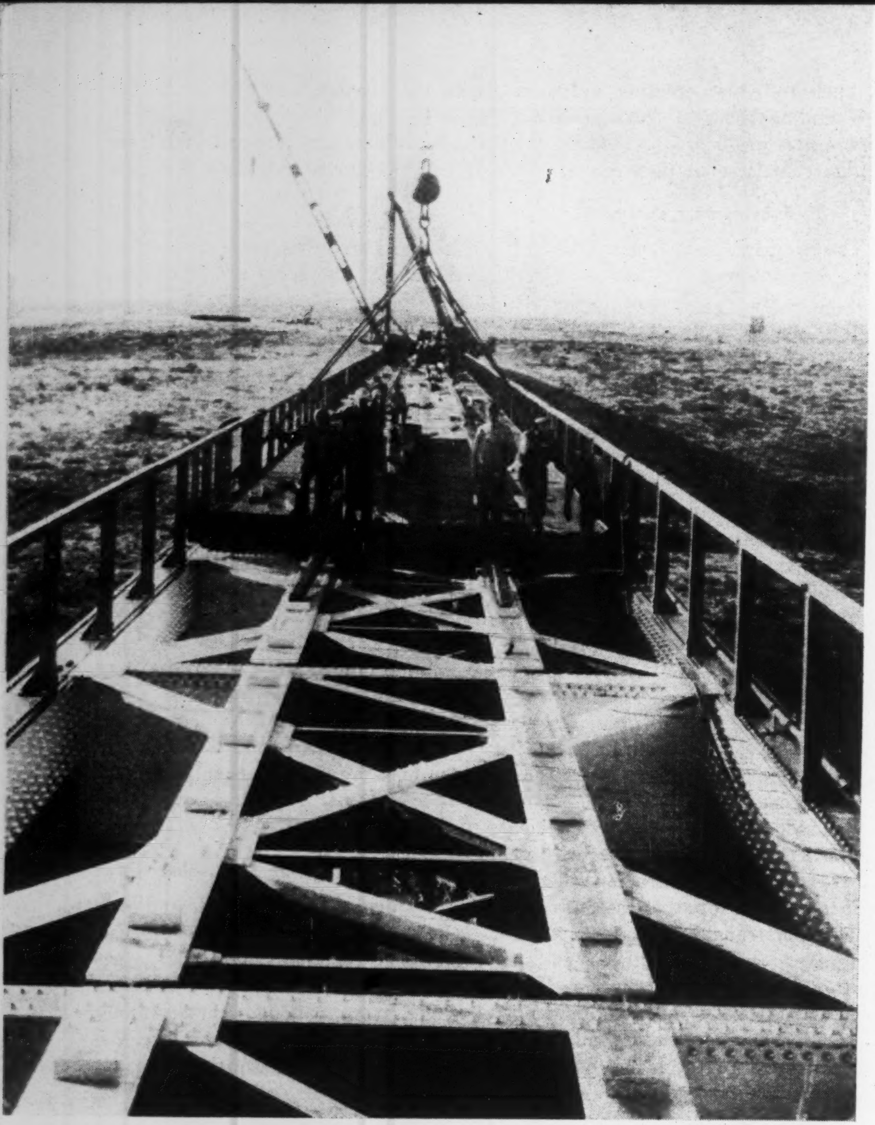
Although preliminary core borings had been made, from four to nine additional holes were now drilled into each footing excavation to verify the soundness of the limestone rock, and no indications of unsatisfactory conditions were found.

Cableway for concreting

Meanwhile, the contractor had built a concrete mixing plant, on the east approach roadbed where the aggregate bins could be charged by crawler cranes from railroad cars, and he erected a cable way from it across the canyon on the centerline of bridge with which to place the concrete. This heavy duty cableway carried a 2-cu. yd. bottom dump bucket, which made as many as eight trips per hour in

Cantilever erection with stiffleg derrick travelers was construction procedure used on new Pecos River bridge. Note contrast of new structure with short spans and light members of old crossing in background.





Deck installed on completed steelwork is characterized by open grating walkways at either side and wrought iron plating in the center to provide corrosion protection for the steelwork and fire protection for the ties.

the pouring of concrete in the bottom of the canyon where 800 ft. of horizontal travel and 275 ft. of vertical travel each way were required.

Because four of the piers had vertical sides, narrowed in steps, it was possible for the contractor to utilize the slip form method of pier construction, as developed by Brown and Root's consulting engineer, C. M. Davis. About 4 ft. high, the slip forms were jacked up slowly as the concrete set by means of 1-in. dia. jacking rods that extended down into the concrete as reinforcement and were spaced from 5 to 7 ft. apart. The forms were braced together by yokes over their tops, and it was against these yokes that the jacking was done.

The pours were started by placing about 12 in. of concrete in the form and then slowing down to a rate of pouring that would fill the forms by the time the concrete in the bottom had taken a sufficient set to permit the jacking operations to start, usually from 6 to 8 hr. Once the jacking was started, the pouring and jacking were continuous, keeping the form full to within 6 in. of the top.

The jacking operation consisted of having a number of men walk around the form and give each jack a partial turn to raise the form $\frac{1}{8}$ to $\frac{1}{4}$-in. Periodic checks were made against level marks placed on the jack rods to maintain the forms level, but since this in itself was not enough to assure the form travelling in a vertical line, it was also necessary to check the vertical travel by plumbing up points with a transit. Any error in vertical travel was corrected by simply advancing the jacks on the side toward which the form had travelled.

For curing purposes, and to cool the mass concrete, a horizontal ring of perforated pipe was fastened to the bottom of the forms, and water was sprayed through it continually against the surface of the concrete. In the case of the cellular piers, sprays were used on both inner and outer surfaces.

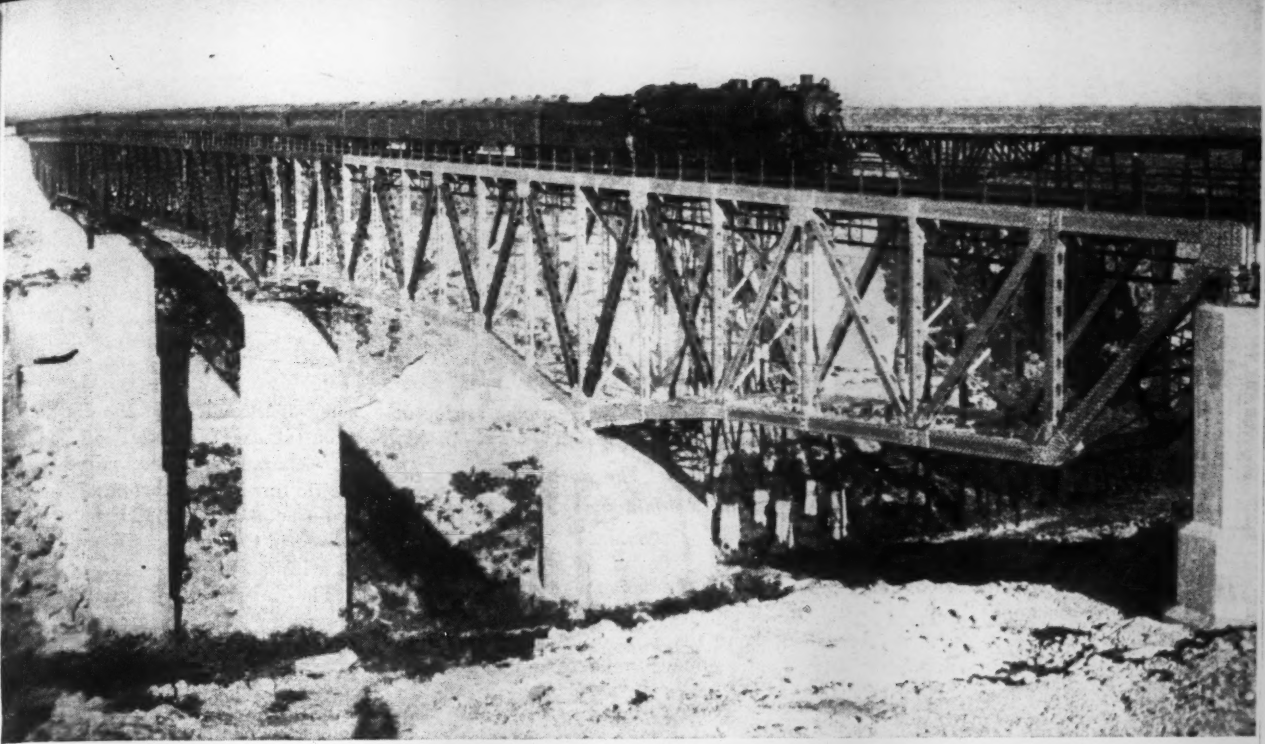
Erection of the superstructure

Bethlehem Steel Co. contractors for the superstructure, for whom E. L. Durkee was resident engineer, planned to start steel erection promptly upon completion of the piers, which was achieved in April 1944, but critical wartime work in their shops held up fabrication to the extent that erection, had it been started then, would have been progressively delayed. The start of erection was, therefore, postponed until July 28, while in the meantime equipment was delivered to the site, and the construction camp was made ready.

The east approach girder span was erected first, followed by the west girder span affording good starting points for the stiffleg derrick travelers that in August began erection of the truss spans from each end of the bridge. Due to wartime shortages, only one erection crew was soon being employed alternately on each side until Oct. 21, when two crews were again available to work simultaneously until the final closing of the center span on Nov. 10.

The end truss spans were erected on falsework, and spans BC and DE were cantilevered over the traction piers. This cantilever erection deflected each of the span ends downward $17\frac{1}{2}$-in. by the time they landed on blocking on the high piers C and D, an amount which closely checked computations. The span ends were then jacked up on piers C and D to their final positions on the shoes. The top chord joints over traction piers B and E were released as required by the design during the cantilever erection of the center span, and when the design cantilever moment over piers C and D had been realized these joints were reamed and riveted under a condition of no stress to produce continuity under all subsequent loads.

It was considered important to



New bridge will carry heaviest railroad loads over deep Pecos gorge, removing the traffic bottleneck caused by the inadequacy of the old structure.

anticipate any concrete shrinkage which might take place in the high piers C and D, and to take account also of any deviation from mean concrete temperature that might exist during erection. Thermometers to measure concrete temperature had been placed in the high piers, and in consideration of conditions existing at the time, only ⅛ and ¼-in. shims were required to be placed for this purpose under the shoes of piers C and D, respectively, when the final steel elevations were established at these points.

The new Pecos River bridge was opened to main line traffic on Dec. 21, 1944. It was built for the Texas and New Orleans Railroad Co. of the Southern Pacific Lines, for which R. W. Barnes, now vice president, was chief engineer. Modjeski and Masters were the engineers for the design and supervision of construction, and were represented in the field by O. F. Sorgenfrei as resident engineer.

Minnesota Creates New Commission For Water Pollution Control

Recent enactment of a water pollution control act by the Minnesota legislature establishes for that state a Water Pollution Control Commission. The new body is composed of the Secretary and Executive Officer of the State Board of Health, the Commissioner of Conservation, the Commissioner of Agriculture, the Secretary and Executive Officer of the Livestock Sanitary Board and a member at large to be appointed by the governor and to hold office for four years.

The new commision has elected as chairman Chester S. Wilson, state conservation commissioner. Samuel P. Kingston, district public health engineer of the State Dept. of Health, has been appointed consultant.

Among the specific duties of the commission as outlined in the act are: (1) Administration and enforcement of all laws relating to pollution of waters of the state; (2) investigation of the extent, character and effect of pollution of the waters of the state, and such classification of those waters as is deemed advisable; (3) establishment and alteration of pollution standards: (4) establishment and alteration of orders requiring discontinuance of discharges resulting in pollution; (5) approval of plans for disposal systems and inspection of their construction; and (6) issuance of permits for the discharge of sewage, industrial wastes and other wastes in accordance with pollution prevention or abatement policies.

Members of the new commission are to receive no additional compensation for their services other than actual traveling and subsistence expenses incurred in connection with the work of the commsision, to be paid from the appropriations of the several departments.

Under this act the control of pollution prevention and abatement seems to rest largely with the State Board of Health, but the political responsibilities must rest with the entire commission.

St. Paul and Minneapolis have long contended that their expensive efforts to end sewage pollution of the Mississippi River by building a disposal plant have been only partly successful because other municipalities and state institutions above these two cities are continuing to pollute the water. This applies especially to the Minnesota River, Rum River and the Upper Mississippi River.

Column Stress by Successive Deflections

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***Contents in Brief**—Factors controlling the stability of a column subjected to direct stress and bending are more clearly visualized through graphic and analytical studies based on successive deflections. The percentage of probable error for short columns is shown to be insignificantly small regardless of the assumed shape of the elastic line during bending.*

AN UNDERSTANDING of column behavior is perhaps best approached through deflection studies. Analysis by the method of successive deflections presents a slow motion picture of the geometry of distortion, enabling the observer to visualize the relation of the factors controlling stability at any given stage. The method presented here was derived by the writer in 1939 and has since been used to advantage by him in his classes. It obviously is not limited to the simple case treated, but can be extended to other cases. So far as the writer knows the procedure has not been published before.

In an eccentrically loaded column (Fig. 1a) the deflection from the initially straight condition to the position at equilibrium or collapse can be viewed as the sum of a series of successive deflections, each being derived from the preceding deflection. Thus y_1 results from flexure under the bending moment Pe; y_2 results from flexures under moments Py_1, while the maximum moment is $P\Delta_1$, etc. The notation used for stress distribution is shown in Fig. 1b.

When the deflection at equilibrium has been found, there remains only an elementary problem in combined bending and axial loading. If the same type of deflection curve can be assumed at all stages, the computations for successive deflections form a power series whose sum can easily be evaluated. Since this procedure may be regarded as experimental mathematics, it is necessary first to investigate three conditions, (1) character of the curve of the elastic line (neutral axis) at start of bending, (2) character of the curve of the elastic line at equilibrium or just preceding collapse and (3) the error involved in the summation and the limits within which the study applies.

The initial curve resulting from moment Pe, is an arc of a circle. However, this arc is so very flat that it differs from a parabola by an infinitesimal amount. The final curve, at equilibrium, is a sine curve. This is easily established from the well known fundamental condition that the moment at any point, Py_0, is the second derivative of the deflection y_0; that is, the curve must be a function whose second derivative is the original function. When e is zero, the curve begins at zero and extends to π. When e has a positive value, the length of the column is less than π.

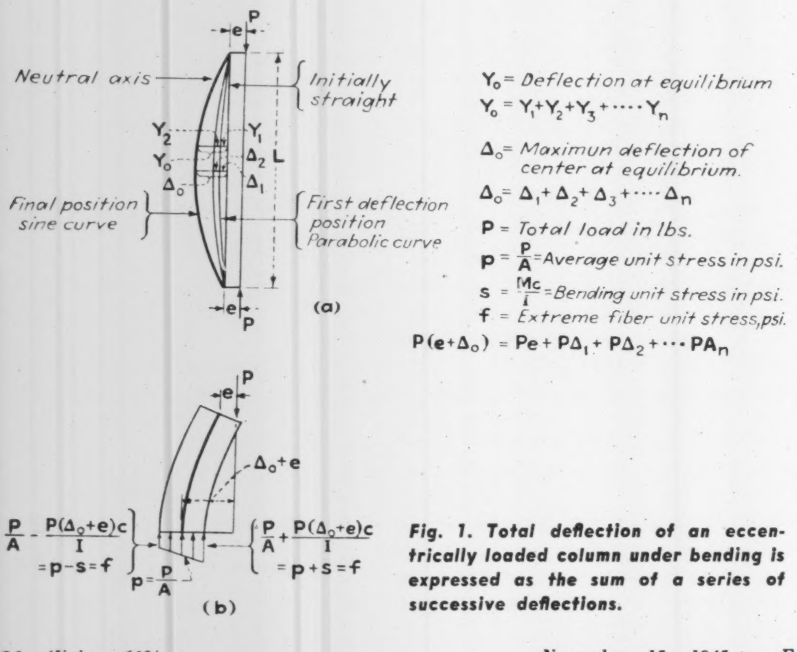

P
e
Neutral axis
Initially straight
Y_2
Y_1
Y_0
Δ_2
L
Δ_0
Δ_1
Final position sine curve
First deflection position Parabolic curve
e
P
(a)
Y_0 = Deflection at equilibrium
$Y_0 = Y_1 + Y_2 + Y_3 + \cdots Y_n$
Δ_0 = Maximun deflection of center at equilibrium.
$\Delta_0 = \Delta_1 + \Delta_2 + \Delta_3 + \cdots \Delta_n$
P = Total load in lbs.
$p = \frac{P}{A}$ = Average unit stress in psi.
$s = \frac{Mc}{I}$ = Bending unit stress in psi.
f = Extreme fiber unit stress, psi.
$P(e+\Delta_0) = Pe + P\Delta_1 + P\Delta_2 + \cdots PA_n$
P
e
$\Delta_0 + e$
$\frac{P}{A} - \frac{P(\Delta_0+e)c}{I} = p - s = f$
$p = \frac{P}{A}$
$\frac{P}{A} + \frac{P(\Delta_0+e)c}{I} = p + s = f$
(b)

Fig. 1. Total deflection of an eccentrically loaded column under bending is expressed as the sum of a series of successive deflections.

Deflection and curvature

It will be helpful at this point to investigate the order of magnitude of the quantities involved in the problem. In Fig. 3 there are shown initial and final deflections and initial and final radii of curvature for a typical structural column (Column A—Fig. 2a) loaded to capacity. It will be noted that for even this rather slender member the initial radius of curvature exceeds one-half mile while the column length is less than 35 ft. There is no measurable difference between a parabola and a circular arc for segments having a ratio of midordinate to chord considerably greater than shown in this example. Even at final deflection the radius of curvature at the center of the member is one-third mile. Hence, it is apparent that no measurable error is involved in assuming the initial curve to be a parabola.

It also is plain from the foregoing, that the curve of the elastic line is warped from a circular arc or parabola to a sine curve as the deflection

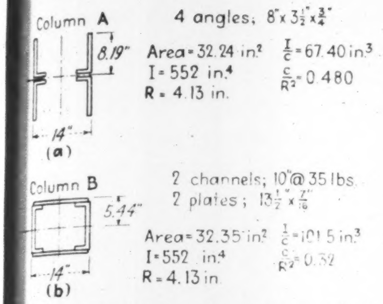

Column A
4 angles; 8"x3½"x¾"
8.19"
Area = 32.24 in.²
I/c = 67.40 in.³
I = 552 in.⁴
c/R² = 0.480
R = 4.13 in.
14"
(a)
Column B
2 channels; 10"@35 lbs.
2 plates; 13½"x7/16"
5.44"
Area = 32.35 in.²
I/c = 101.5 in.³
I = 552 in.⁴
c/R² = 0.32
R = 4.13 in.
14"
(b)

Fig. 2. Typical column sections analyzed include one made up of four angles (a) and another made up of plates and channels as shown in (b).

of the column progresses under a given load. Using either the moment area or the elastic weight method, the center deflection of the column is given by the product of the area of half of the M/EI diagram multiplied by the distance from the end of the member to the centroid of this same area. This product is $\frac{5}{48}L^2\Delta$ for the parabolic segment and $\frac{L^2}{\pi^2}\Delta$ for the sine segment (Fig. 4).

Investigation shows that for a column having small L/R values (the most common case for structural members) either the parabola or the sine curve may be assumed for the computation of successive deflections, but as the values of L/R increase the parabola gives deflections considerably too large while the sine curve gives deflections slightly below the true values (Fig. 5), deflections obtained by the theoretically correct secant formula being assumed as the standard of measurement.

Effect of assumed length

The discrepancy between the sine curve values and the secant formula values arises from the assumption that the sine curve extends from O to π, whereas the column length is actually shorter, as noted above, when e has a positive value.

This study shows that the maximum error in deflection when a sine curve is assumed is about 3 percent for the most slender columns, and 2 percent for members having an L/R value of 100. The percentage of error in the unit stresses is obviously considerably less. Hence, the sine curve is assumed in the derivation, the limits of accuracy being understood to be as just stated. Correction for this small error has been made in computing the deflection curves shown in this paper.

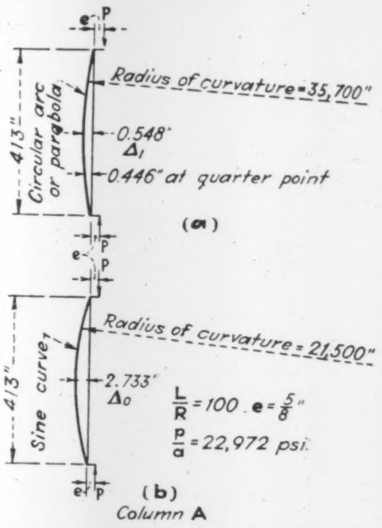

e
P
Radius of curvature = 35,700"
Circular arc or parabola
4/3"
0.548"
Δ₁
0.446" at quarter point
(a)
e
P
Radius of curvature = 21,500"
Sine curve
4/3"
2.733"
Δ₀
L/R = 100 . e = 5/8"
P/a = 22,972 psi.
(b)
Column A

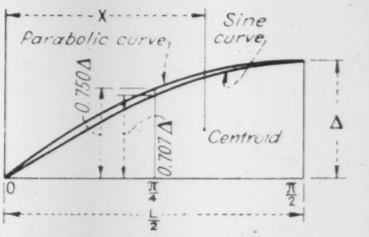
Fig. 3. Actual radii of curvature for ordinary columns are large at initial bending (a) and final curvature (b) relative to column dimensions.

Successive and total deflections

The derivation of the expression for successive deflections and for total deflection (Fig. 6) is self-explanatory. Three conclusions follow at once from inspection of Equations (3) and (4):

1. The column is stable, *i.e.* the series is convergent, as long as each successive deflection is less than the preceding deflection. The criterion for this is that $\Delta_1 > \Delta_2$. This is the condition for the ordinary column and it applies provided always that the elastic limit strength of the material has not been exceeded.

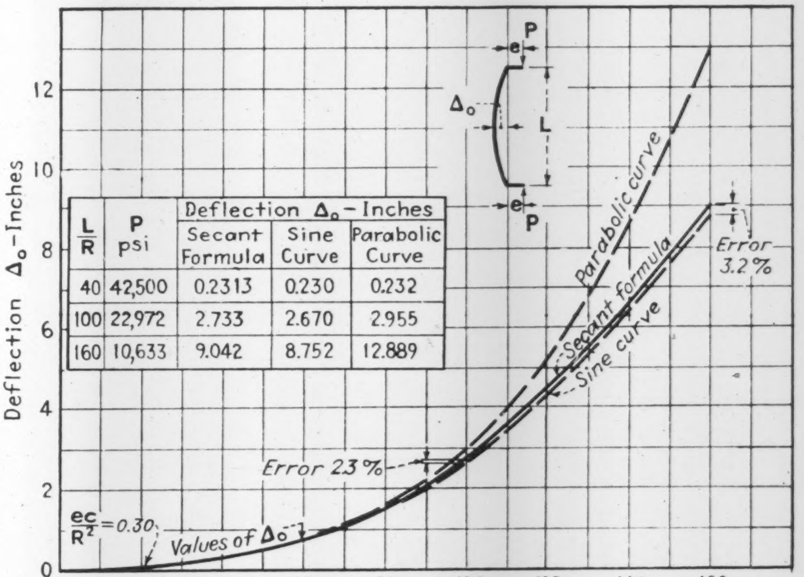
2. The column becomes unstable, *i.e.* the series does not converge, when each successive deflection is equal to the preceding one. The criterion for this is $\Delta_1 = \Delta_2$. This is the condition for the well known Euler load and it applies provided always that the elastic limit strength of the material has not been passed by the aver-


X
Parabolic curve
Sine curve
0.750 Δ
0.707 Δ
Centroid
Δ
0
π/4
π/2
L/2

Properties of Segment Area

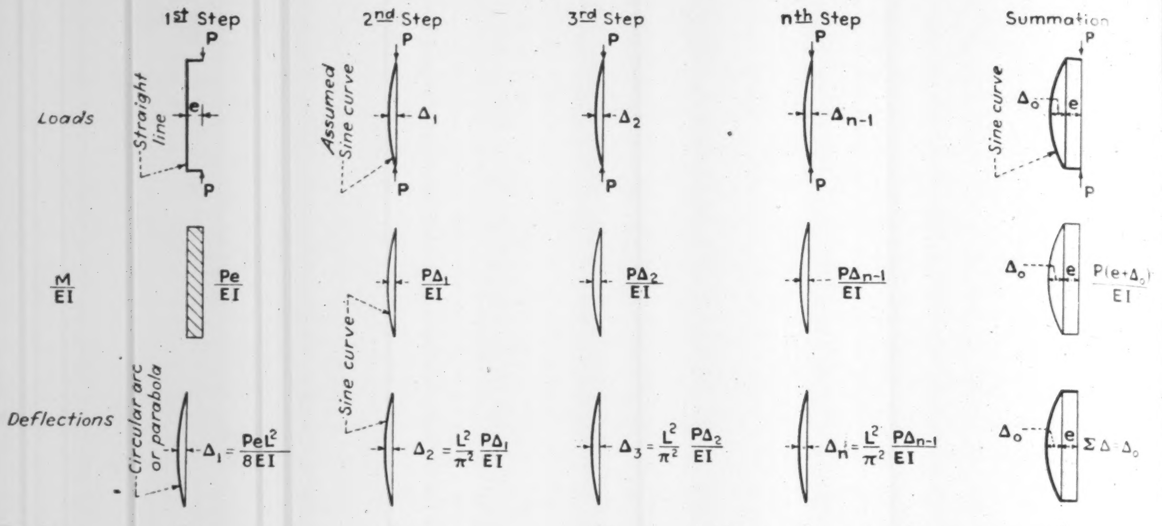
	Sine curve	Parabolic curve
Area A:	$\frac{2}{\pi}\times\frac{L}{2}\Delta=\frac{L}{\pi}\Delta$	$\frac{2}{3}\,\frac{L}{2}\Delta=\frac{L}{3}\Delta$
Distance X:	$\frac{2}{\pi}\times\frac{L}{2}=\frac{L}{\pi}$	$\frac{5}{8}\,\frac{L}{2}=\frac{5}{16}L$
AX:	$\frac{L^2}{\pi^2}\Delta=0.1013\ L^2\Delta$	$\frac{5}{4}\,\frac{L^2}{8}\Delta=0.1042\ L^2\Delta$

Fig. 4. Properties of segment areas under a sine curve approximate those under a parabolic curve.



L/R	P psi	Deflection Δ₀ – Inches		
		Secant Formula	Sine Curve	Parabolic Curve
40	42,500	0.2313	0.230	0.232
100	22,972	2.733	2.670	2.955
160	10,633	9.042	8.752	12.889

Fig. 5. Deflections of Column A (Fig. 2a) assuming an elastic limit of 60,000 psi., show close agreement between the sine curve and that by the secant formula.


1st Step
2nd Step
3rd Step
nth Step
Summation
Loads
P
e
Straight line
Assumed Sine curve
Δ1
Δ2
Δn-1
Sine curve
Δo
M/EI
Pe/EI
PΔ1/EI
PΔ2/EI
PΔn-1/EI
P(e+Δo)/EI
Deflections
Circular arc or parabola
Δ1 = PeL²/8EI
Δ2 = L²/π² PΔ1/EI
Δ3 = L²/π² PΔ2/EI
Δn = L²/π² PΔn-1/EI
ΣΔ = Δo

Eq 1: $\Delta_1 + \Delta_2 + \Delta_3 + \cdots\cdots \Delta_n = \Delta_o$

Eq 2: $\frac{PeL^2}{8EI} + \left[\frac{L^2}{\pi^2}\frac{P}{EI}\right]\frac{PeL^2}{8EI} + \left[\frac{L^2}{\pi^2}\frac{P}{EI}\right]^2\frac{PeL^2}{8EI} + \cdots\cdots \left[\frac{L^2}{\pi^2}\frac{P}{EI}\right]^{n-1}\frac{PeL^2}{8EI} = \frac{\frac{PeL^2}{8EI}}{1-\frac{L^2}{\pi^2}\frac{P}{EI}}$ when $\frac{L^2}{\pi^2}\frac{P}{EI} < 1$

or

Eq 3: $a + r \times a + r^2 \times a + \cdots\cdots r^{n-1} \times a = \frac{a}{1-r}$ when $r < 1$

Eq 4: then $\Delta_o = \frac{\frac{pe}{8E}\left(\frac{L}{R}\right)^2}{1-\frac{p}{\pi^2 E}\left(\frac{L}{R}\right)^2}$ when $\frac{p}{\pi^2 E}\left(\frac{L}{R}\right)^2 < 1$

where: P = Total load in pounds
R = Radius of gyration
L = Length in inches

$p = \frac{P}{A}$ = Average unit load
A = Area

Fig. 6. Total deflection of the column equals the summation of the successive deflections as indicated, step by step.

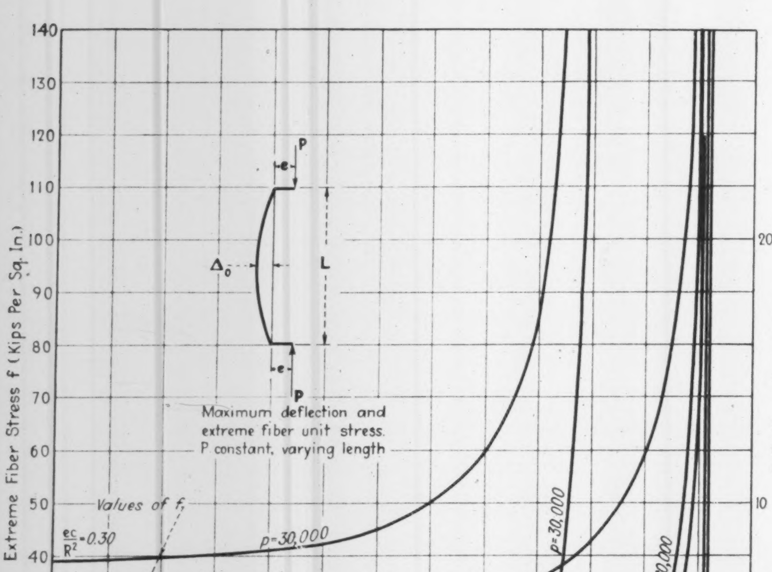


Fig. 7. Maximum deflections and extreme unit stresses for Column A (Fig. 2) vary according to the length when subjected to a constant load.

age unit stress in the column.

3. A clear picture of column action is given by study of the variation of total deflection and extreme fiber unit stress as L/R is increased for a given column.

Discussion of the foregoing conclusions is desirable. Attention is directed to Fig. 7 which shows: (1) The relation of deflection to L/R for a given column with constant load. (2) The relation of extreme fiber unit stress on the section to deflection as L/R varies for a given column with constant load. (3) The effect on deflection and maximum unit stress of increasing the load and (4) the effect on deflection and maximum unit stress of increasing the eccentricity.

It is desirable to inspect the expression for total deflection. Equation (4) has the general form:

$$y = \frac{Ax^2}{1 - Bx^2}$$

The curves in Fig. 7 show that the increase of Δ_o with L/R is slow and approximately uniform until the Euler value of L/R is approached, when the rate of increase rises rapidly until it becomes infinite.

The curves in Fig. 7 for extreme fiber unit stress f conform to the de-

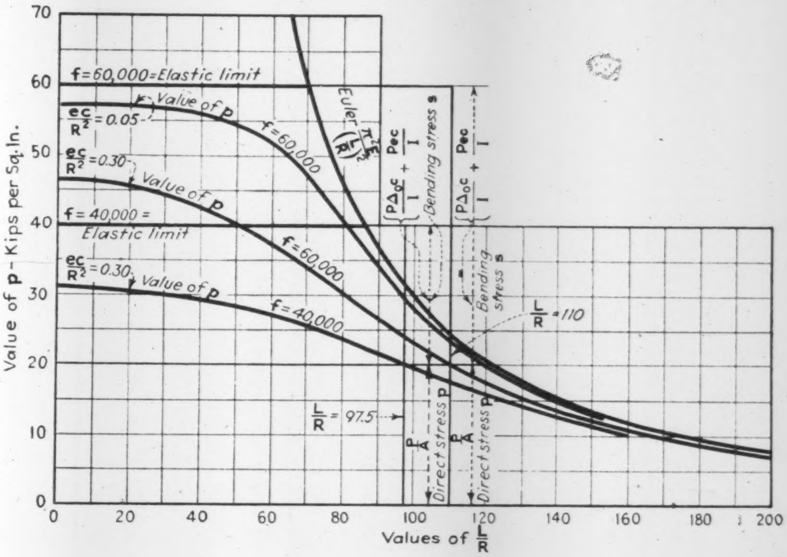


Fig. 8. Relationship between axial stress, bending stress and elastic limit strength for all values up to the buckling value of the column conforms to a definite pattern.

flection curves. When *e* is zero, the unit stress is uniformly distributed; i.e., there is no bending, and no deflection occurs theoretically until the Euler value of L/R is reached; viz.,

$$\frac{L^2}{\pi^2} \times \frac{P}{EI}$$

(Equation 2 in Fig. 6), when unlimited deflection suddenly occurs accompanied by unlimited bending, producing collapse by elastic buckling. When *e* has a positive value, bending is present for all values of L/R.

For very low values of L/R the deflection is negligible, the bending moment is Pe and the unit stress f is $P/A + Pec/I$. As the column is lengthened and the deflection becomes appreciable the bending moment is $P(e + \Delta_0)$ and the unit stress due to bending is increased in proportion. Provided that the elastic limit strength of the steel is not exceeded by f, the column is still stable.

When the deflection curve starts to break upwards, the unit stress f increases very rapidly, but the column is stable provided the elastic limit of the material is high enough to equal f. When the deflection curve becomes vertical, collapse must follow from general bending or buckling regardless of the strength of the steel. Thus, it is plain that instability from buckling is a function of L/R and not of material strength. Below this buckling strength, stability depends on the elastic limit strength of the steel.

It is convenient to draw a curve showing the relation between axial unit stress p, bending unit stress s and elastic limit strength of the steel for a given column loaded to capacity for all values up to the buckling value. Three such graphs are given in Fig. 8. Ordinarily regarded as the graph of a column formula, it is apparent that this type of curve is fundamentally the graph just described.

Referring to Fig. 8, it also may be seen that a given column composed of material with an elastic limit of 40,000 psi. will carry a given load due to, say, an average unit stress of 20,000 psi., up to an L/R of 97.5, while the same member, if made of material with an elastic limit of 60,000 psi., will carry the same load up to an L/R of 110. In the first case the bending unit stress is half the total extreme fiber unit stress, while in the latter case it is two thirds of the total unit stress. Furthermore, it is plain that no increase of elastic limit strength, however large, can lift the column load above the Euler value.

The last observation is illustrated by Fig. 9, which shows the relationship between deflection and extreme fiber unit stress as the load is increased on a column with a fixed length.

Effect of form of section

The effect of the form of the cross section on column capacity is shown by the curves in Figs. 9 and 10. Given two columns having the same length, the same cross sectional area, the same I and the same load and eccentricity but one column having a greater distance c than the other, the following occurs: the columns being equally stiff will deflect equal amounts under the same load, but the extreme fiber unit stress on the one will be constantly greater than on the other and hence will reach the elastic limit of the material at a shorter length or lower load than the second member.

This example follows the classic illustration given in "Modern Framed Structures Design," Vol. 3, by Johnson, Bryan and Turneaure, p. 70, Ed. 9. Hence it is clear that a rational column formula must include the term e to represent bending moment and the term c to represent extreme fiber unit stress.

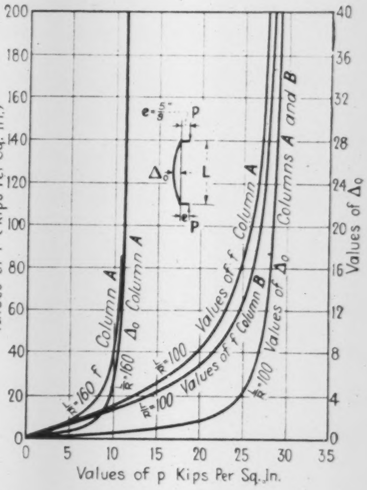


Fig. 9. Maximum unit stresses for Columns A and B (Fig. 2) depend upon the makeup of the section, using a fixed length of column under a variable load.

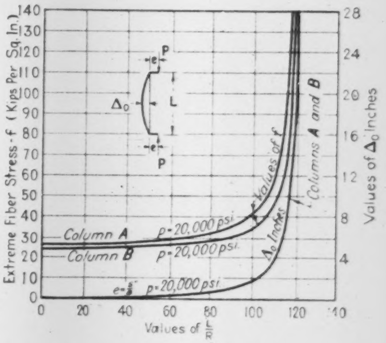


Fig. 10. Columns A and B (Fig. 2) of varying lengths but under a constant load also have different unit stresses due to their different values of c.

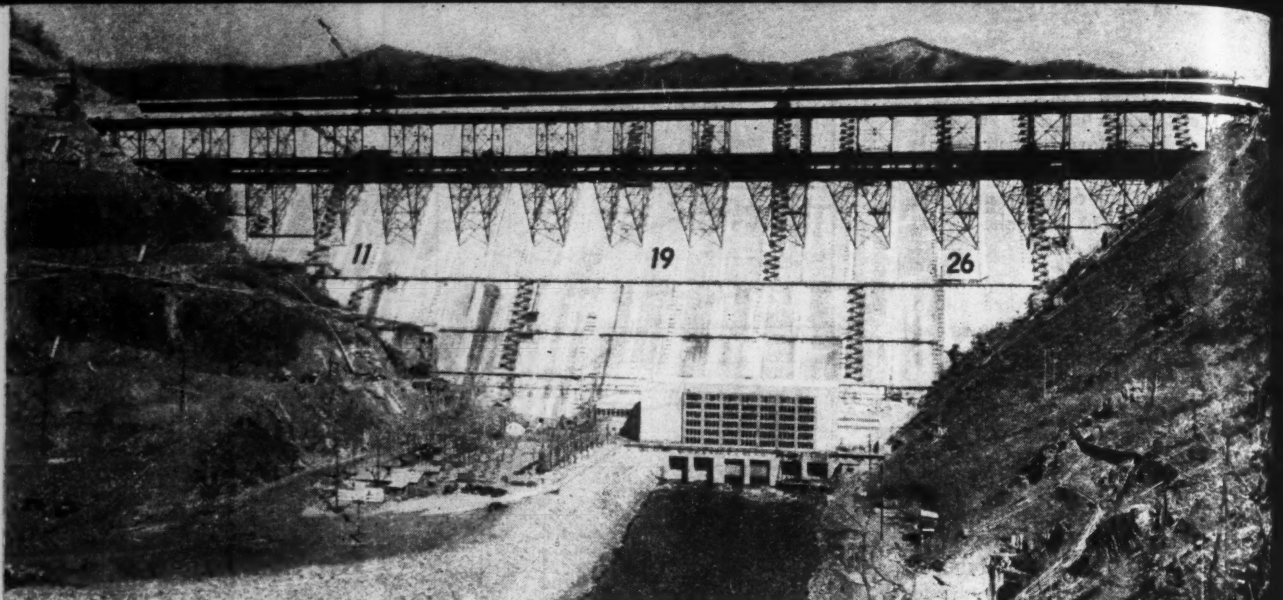


Fig. 1. Instruments to determine the movement of concrete in Fontana Dam were placed in Blocks 11, 19 and 26.

Structural Behavior of Fontana Dam Revealed by Dual-Purpose Instruments

W. R. Waugh

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Contents in Brief*—Investigation of structural behavior of Fontana Dam is being carried on with the aid of special measuring instruments installed to give information for control of cooling and joint grouting. Data is sought on the strain and stress near the base of the maximum section of the dam and boundary conditions at the upstream and downstream faces. Meters are installed across longitudinal and transverse joints to determine changes at contraction joints, to observe movements of adjacent blocks during grouting and to check subsequent changes.*

AN EXTENSIVE INSTALLATION of special measuring instruments was made at Fontana Dam, recently completed by the Tennessee Valley Authority, to serve a two-fold purpose—to examine the structural behavior of the dam in service; and to provide information for controlling some phases of the construction operations, such as cooling and joint grouting as well as to observe the effectiveness of other phases, such as foundation grouting. A description of Fontana Dam and its construction appeared in *Engineering News-Record* Nov. 16, 1944, vol. p. 633 and Nov. 30, 1944, vol. p. 689.

The justification for a comprehensive installation to examine structural behavior alone would be debatable under existing conditions but this installation was indispensible for control of concrete cooling and joint grouting operations. Many engineers agree, however, that for a dam of this magnitude and importance an installation of instruments for investigation of structural behavior is justified under any circumstances. Ordinarily, the different character of data required for construction and for long time behavior, would indicate a difference in arrangement of some of the instruments, but by judicious choice of locations for the test devices, both purposes are served effectively.

Instruments embedded in the concrete are used for measurement of strains, compressive stresses, contraction joint openings, interior concrete temperatures, foundation uplift pressures, interstice or pore pressures in the interior of the concrete of the dam, and deflection. Auxiliary portable and semi-portable instruments are used for measuring concrete temperatures and for observing joint movements during joint grouting operations.

Electrical instruments, including 150 Carlson strain meters, 8 Carlson stress meters, 82 Carlson joint meters, and 79 Carlson resistance thermometers, have been embedded in three typical blocks of the dam. The instruments, made by Prof. Roy W. Carlson of the University of California, measure strains, stresses, joint openings and temperatures. (For description of the meters see *ENR* May 16, 1935, p. 696.) The strain meters, stress meters and joint meters are dual-purpose instruments and are used here to measure temperature and strain, stress or joint opening as required.

Location of instruments

The strain and stress investigation is in two parts. One part is intended to determine the stresses and strains near the base of the maximum section. For this investigation eight duplicate groups of meters are installed near the base of one of the central blocks, No. 19. In Fig. 3 is shown the arrangement of these meter groups in block No. 19.

In each group of meters (Fig. 3) on the centerline of the block, four strain meters are arranged to measure strain in four directions in a vertical plane normal to the axis of the dam. One strain meter is arranged to measure horizontal strain parallel to the axis; one stress meter is arranged to measure vertical compressive stress, and one strain meter, called a "no-stress meter", is provided to measure length change resulting from stress-free volume change. The no-stress meter is embedded in a cylinder of concrete that is placed in a cavity in the mass concrete of the dam. The duplicate groups of meters, placed at the left edge of the blocks, are identical except that the stress meter is not included.

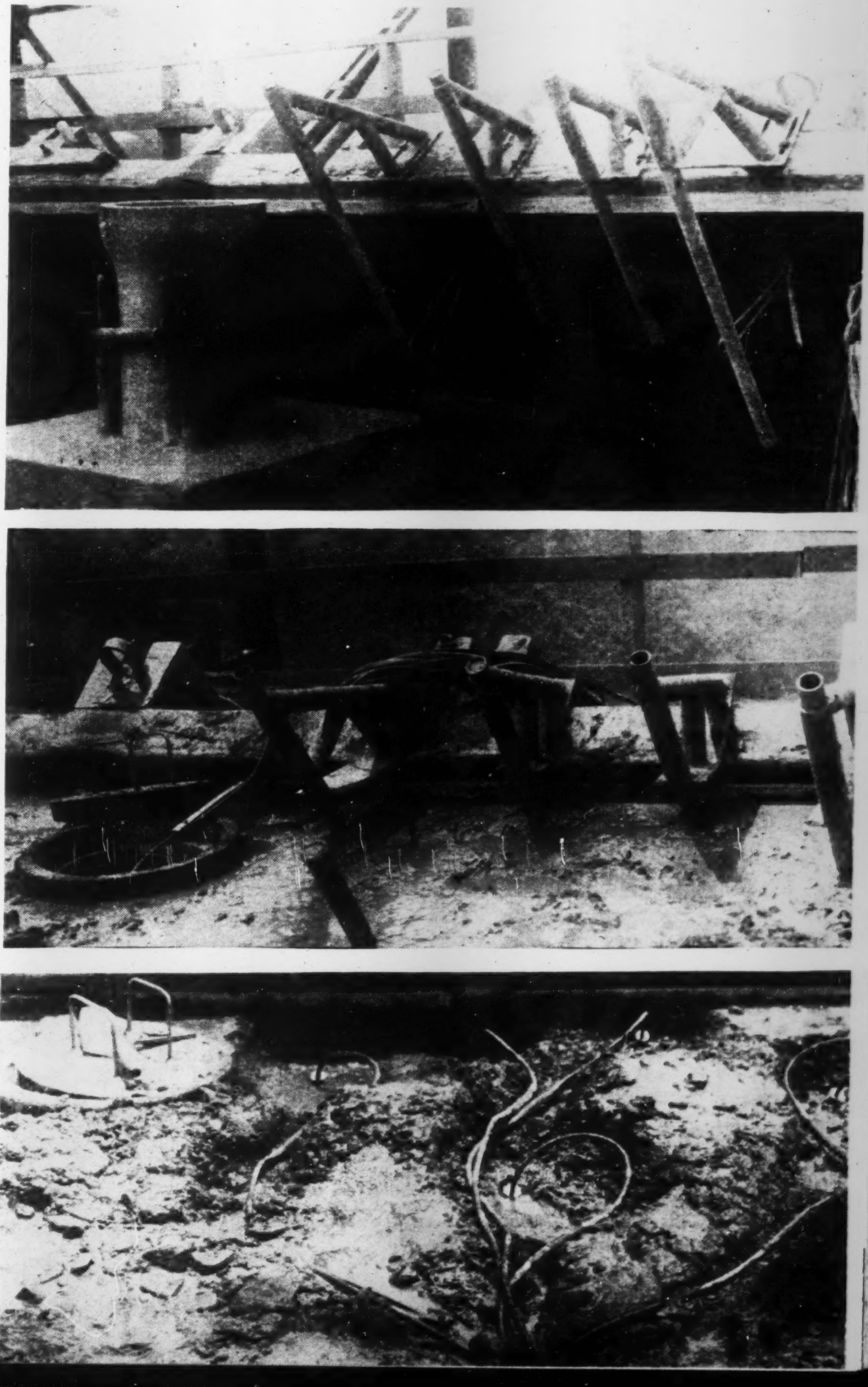
Meters also in upstream column

In addition to the main groups of test equipment, two smaller sets of duplicate groups of three meters each are installed in the upstream column, A, and one set in the adjacent column, B. (Fig. 3). In these groups, two of the meters measure vertical and horizontal strains, respectively, in a plane normal to the axis and the other meter measures horizontal strains parallel to the axis of the dam. In this installation 120 meters are included, of which 47 are used also for temperature measurements.

The other part of the strain and stress investigation is intended to determine boundary conditions at the upstream and downstream faces. For this investigation three sets of strain meters were installed near the upstream face and three identical sets near the downstream face. All of these meters are used for both temperature and strain measurements. Two of the three sets (Fig. 3, Details Q and S) at each face contain five meters placed parallel to the face in a vertical plane; and one "no-stress" meter. The third set (Fig. 3, Details R and T) is composed of three meters similarly arranged. Brackets, especially designed to fix the exact location of the holes in the fresh concrete (Fig. 2), were attached to the forms for embedding these meters. The value of this part of the program is very largely determined by the precision with which the meters are set.

Meters were installed across longitudinal joints in three typical blocks (11, 19 and 26) and across three transverse joints between typical blocks (19-20, 25-26 and 26-27). Joint meters used have maximum ranges of about $\frac{1}{4}$ in. and $\frac{1}{3}$ in. The short range, $\frac{1}{4}$ in., meters are used

Fig. 2. *Value of instruments installed near the face depends largely on the precision with which meters are set. Adjustable brackets fix position. After concreting, brackets are removed, strain meters are placed and then covered with concrete.*



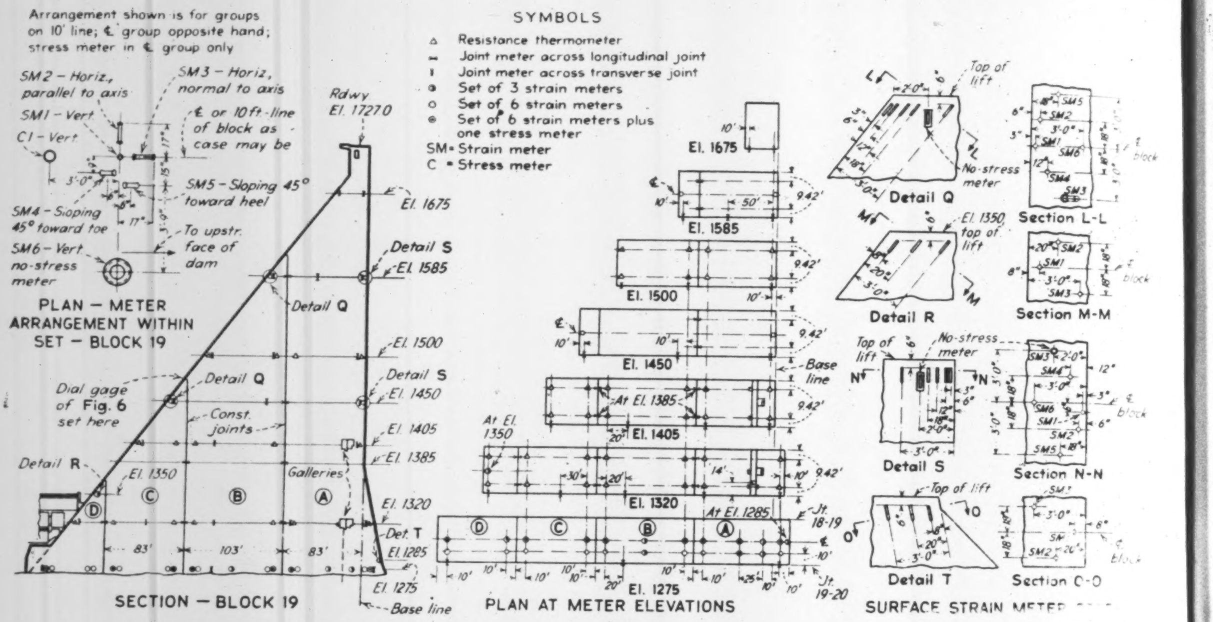

Arrangement shown is for groups on 10' line; ℄ group opposite hand; stress meter in ℄ group only
SM2 – Horiz., parallel to axis
SM3 – Horiz., normal to axis
SM1 – Vert.
C1 – Vert.
℄ or 10 ft.-line of block as case may be
SM5 – Sloping 45° toward heel
SM4 – Sloping 45° toward toe
To upstr. face of dam
SM6 – Vert. no-stress meter
PLAN — METER ARRANGEMENT WITHIN SET — BLOCK 19
Rdwy El. 1727.0
El. 1675
Detail S
El. 1585
Detail Q
El. 1500
Dial gage of Fig. 6 set here
Detail Q
Detail S
El. 1450
Const. joints
El. 1405
El. 1385
Detail R
El. 1350
Galleries
D
C
B
A
El. 1320
Det. T
El. 1285
83'
103'
83'
El. 1275
Base line
SECTION — BLOCK 19
SYMBOLS
△ Resistance thermometer
▬ Joint meter across longitudinal joint
▮ Joint meter across transverse joint
● Set of 3 strain meters
○ Set of 6 strain meters
⊙ Set of 6 strain meters plus one stress meter
SM = Strain meter
C = Stress meter
El. 1675
El. 1585
El. 1500
El. 1450
At El. 1385
El. 1405
At El. 1350
El. 1320
At El. 1285
El. 1275
9.42'
Base line
Jt. 18-19
Jt. 19-20
PLAN AT METER ELEVATIONS
Detail Q
Top of lift
No-stress meter
Section L-L
Detail R
El. 1350, top of lift
Section M-M
Detail S
Section N-N
Detail T
Top of lift
Section O-O
℄ block
SURFACE STRAIN METER

Fig. 3. Location of instruments imbedded in Block 19 for determination of movement and behavior of the concrete.

across transverse joints where shrinkage of only 50 ft. of concrete had to be measured and the longer range for longitudinal joints, spaced as much as 99 ft. apart. All joint meters, with minor exceptions, also are used for temperature measurement.

Resistance thermometers were installed in three typical blocks (11, 19 and 26) to supplement temperature data from the other embedded instruments for adequate temperature information to control cooling. Seven thermometers are embedded about 3 in. from the upstream face of Block 19 at spacings of 25 to 45 ft. vertically for a height of 200 ft. to measure reservoir water temperatures. Thermometers are embedded in concrete placed to plug tunnels for the purpose of checking completion of cooling so that grouting to fill shrinkage spaces might be accomplished at the earliest possible moment.

Foundation uplift pressures are being investigated in three blocks by means of an installation of cells whereby intensity of pressure at several locations from upstream to downstream may be measured. Typical layout of cells on the foundation of Block 19 and the details of the cell are shown in Fig. 4. Pressures are measured by Bourdon tube pressure gages if the pressure gradient is higher than the reading station or by measuring down to the level of the water in the pipe system if the gradient is below the level of the reading station. These cells offer a valuable check on effectiveness of curtain grouting and foundation drains as the reservoir is being filled.

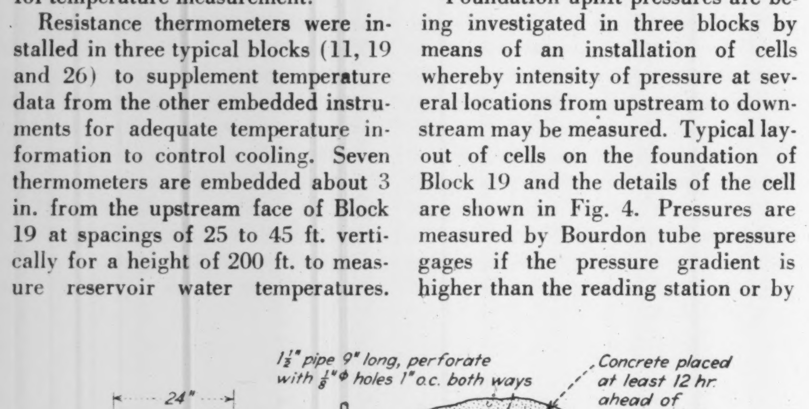

1½" pipe 9" long, perforate with ⅛"φ holes 1" o.c. both ways
Concrete placed at least 12 hr. ahead of covering lift
24"
1½" pipe
16"
Pea gravel
6"
10"
Plan
DETAIL OF CELLS
Cap
3'-8"
4'-0"
Section
Spread pipes to 8" at risers
Fnd. drain holes
Jt. 18-19
BLOCK 19
5'
15 risers
℄
5 risers
Jt. 19-20
50'
50'
50'
50'
40'
30'
20'
10'
10'
5'
Base line
Location of Uplift Cells on Foundation

Fig. 4. Cells placed on foundation rock are used to indicate uplift pressure of water at the concrete-rock contact line.

Pressures inside the concrete

Pore pressures inside the dam near the upstream face are being investigated at two elevations (El. 1,320 and El. 1,405) which will be subject to 390 and 305 ft. of head when the reservoir is full. Two types of instruments are used for this purpose.

One of these is a hydrostatic pressure cell developed by the Bureau of Reclamation. Six units are installed at El. 1,320 at distances of 1 ft. to 12 ft. from the upstream face; fourteen are installed at El. 1,405 at distances of 6 in. to 12 ft. from the upstream face. Essentially these instruments are a cylindrical cell in which a diaphragm is held. Air pressure is applied to the inside of the cell to offset water pressure against the diaphragm from the outside. When slightly more air pressure than water pressure is applied inside, the diaphragm is moved enough to break an electrical circuit and put out a light. The moment the light goes out the air pressure is observed and recorded as the water pressure on the cell.

The other cell is also made by the

Bureau of Reclamation and is called a "piezometer tip" cell. Six of these are installed at El. 1,320 at distances of 6 in. to 42 in. from the upstream face. This cell is a hollow plastic cylinder one end of which holds a porous disc to admit water into the cell. Attached to the other end are two plastic tubes that lead from the cell to a reading station in the gallery. A Bourdon tube gage is attached to one tube and the other is used to remove the air and fill the tubes and cell with water.

Movement checked by plumb lines

Deflection is being measured in two typical blocks by means of suspended plumb bobs and suitable measuring devices. One installation is in Block 19 and consists of two plumb lines. One line is suspended from near the top of the dam. El. 1,714 and extends to the gallery at El. 1,315 with reading stations at El. 1,315 and El. 1,405. The second line is suspended from a point about 125 ft. below the top of the dam at El. 1,604. A reading station is provided on this line at El. 1,405.

The other plumb-line installation is in Block 26, a side hill block in one of the abutments. This also consists of two lines suspended from the same elevations as in Block 19. One reading station is provided for each of these lines at El. 1,465. The plumb lines are 1/64-in. stainless steel piano wire and the plumb bobs are made of brass and weigh 14 to 17 lb.

Each reading station has four bars that are anchored in the concrete at 45 deg. with the axis of the dam, Fig. 5. Two of the bars hold glass scales, graduated for a length of 2 in. to hundredths of an inch. The other two bars provide means for clamping a filar-head micrometer microscope in position for relating the position of the wire to the scale. Least possible reading with the microscope is 0.0001 in. Accuracy of the readings is probably 0.0005 in.

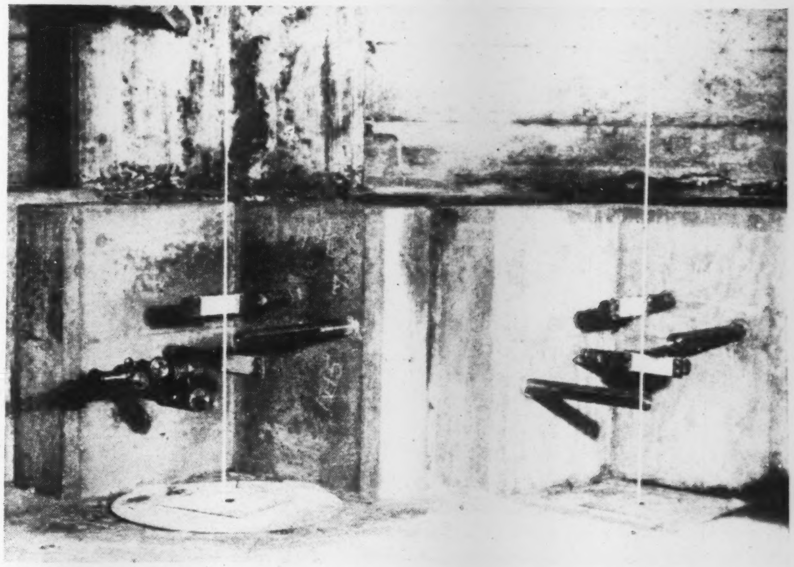


Fig. 5. Plumb lines as much as 400 ft. long are used to check movement of the dam. A filar-head micrometer microscope is used for two directional readings with an accuracy of 0.0005 in. (Plumb lines are retouched for clarity)

Use of installed instruments

During construction the embedded electrical instruments which measure temperature were used as the base control for the cooling operation. Temperature histories (Fig. 6) in three typical blocks were thus made available for evaluating cooling results in locations where no precise means of measuring concrete temperatures was available. Supplementary temperature data was obtained by use of portable resistance thermometers. Pipes into which the portable thermometers are inserted were imbedded in all even numbered blocks at intervals of 25 ft. vertically on the downstream side of the dam; a few were placed on the upstream side and some in the galleries.

Joint meters in the typical blocks have furnished basic data for evaluating joint openings throughout the rest of the dam. Normal joint openings in longitudinal joints vary from 0.085 in. for concrete placed in fall and winter at low temperatures (55 deg. F ±) to 0.237 in. for concrete placed in summer at high temperatures (75 deg. F ±). Normal joint openings in transverse joints vary from 0.054 in. for concrete placed in the fall at moderate temperatures (63 deg. F. ±) to 0.185 in. for concrete placed at high temperatures (75 deg. F. ±) in summer.

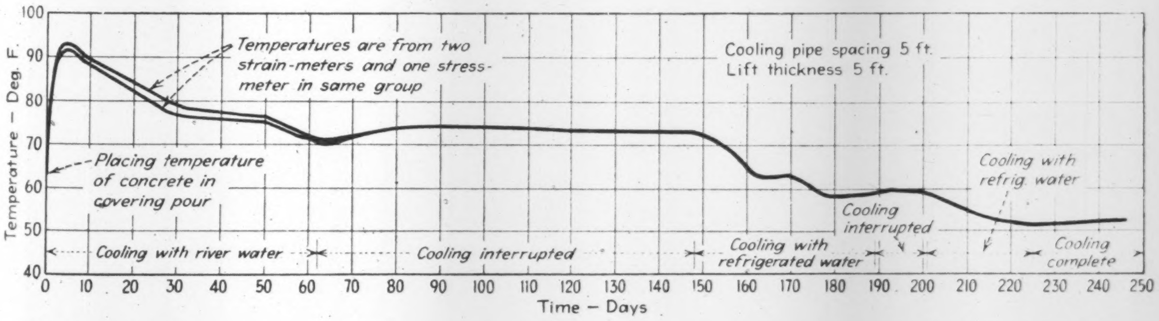


Fig. 6. Typical time-temperature chart showing temperature changes in concrete as river water, then refrigerated water, cooled the concrete to expected constant temperature. Refrigerated water entered the concrete at about 40 deg. F. and returned at 50 deg.

Smallest joint opening recorded is 0.020 in. across a transverse joint where concrete placing in the adjacent, following block lagged the leading block by about 4 months. Concrete was placed in both blocks at low temperatures (48 to 56 deg. F.) and cooling in the leading block was substantially complete before the following block was poured.

Largest joint opening recorded is 0.348 in. near the top of the A-B joint. This abnormally large joint opening reflects the effect of bending in columns A and B due to cooling at the upstream and downstream faces, superimposed on the normal horizontal shrinkage due to the cooling of the mass. Observations of changes in joint opening during joint grouting operations have been used as a basis for judging extent of movement to be expected when grouting at the recommended pressures.

Dial gage observations

Supplementary observations of column movements during joint grouting have been made by means of dial gages (Fig. 7) installed at the tops of joints on the downstream side of the dam and in galleries. Simultaneous joint meter and dial gage readings were made in the typical block as a basis for evaluating the effectiveness of dial gage observations as a guide to controlling column movements during grouting. In one typical block the dial gage indicated an opening of 0.023 in. at the top of a joint at the time of maximum grout pressure when grouting an area 85 ft. below the top of the joint. Simultaneous joint meter readings on meters 10 ft. below the top of the joint indicated an opening of 0.0184 in. and on meters at 25 ft. above the grout zone indicated an opening of 0.0169 in. These observations were made in cold weather when the joints were completely open at the top.

Dial gage observations were discovered to be unreliable in summer when concrete temperatures are high near the downstream surface and the tops of columns are in contact at the contraction joints even though cooling was complete in the main body of the dam where joint grouting was in progress. Joint meter observation, however, assured that no dangerous deflections were resulting from joint grouting. Dial gage observations proved entirely reliable in winter when surfaces of the concrete were cool and joints were entirely open.

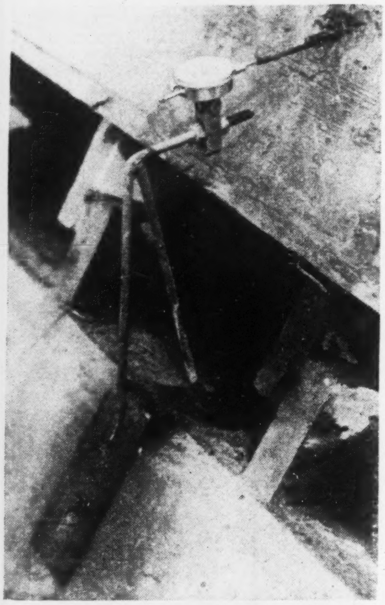
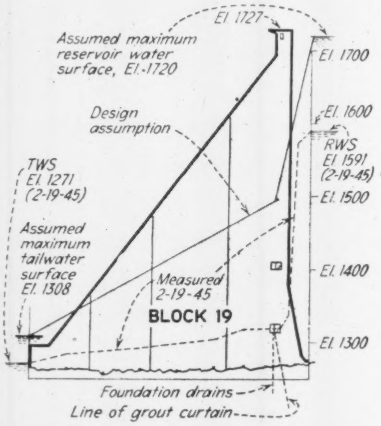


Fig. 7. Dial gage mounted to indicate joint movement for control of column deflection while grouting.

Effect of reservoir filling

Foundation uplift pressures measurements began simultaneously with the filling of the reservoir. Measurements are being compared to assumed uplift pressures as a basis for determining whether additional foundation drains or curtain grouting will be required. In Fig. 8 is shown uplift conditions in Block 19 with the reservoir at El. 1,591. Indications are that foundation drains and grout curtain are very effective in keeping intensity of uplift pressures well below the assumed, and no further treatment will be necessary at this time.



NOTE: Uplift pressures assumed to vary from reservoir pressure at the heel to 50% of reservoir pressure at the line of drains, to tail water pressure at the toe. Pressure assumed to act over 2/3 of base area.

Fig. 8. Uplift pressures on the dam due to water in the reservoir.

Summer grouting proved futile

The deflection measurements have proven valuable in confirming evidence concerning the condition of the top grout sections in the longitudinal joints. Attempts to grout these areas in the summer proved futile and indicated that they were tight although adjacent concrete in the upstream column was "cooled out". Continuous upstream deflection of Column A all summer confirm this conclusion. As a result of these observations additional joint meters were installed in four blocks near the top of the A-B joint for use in determining the time when similar joints B-C and C-D would be groutable. Data from the meters indicated that these joints were groutable by Dec. 1, 1944. Grouting was resumed at that time and executed without difficulty, further emphasizing the value of these instruments for controlling this phase of the construction program.

Continuous use of data

Almost daily reference is made to data from some phase of the program as a guide to future operation or as a check on some phase of the construction progress. After construction, recording of data will continue for several years. Analysis of the data will furnish valuable information on actual behavior as compared to predicted behavior. Temperatures of the interior, near the base were nearly stabilized when the reservoir filling began. This offered an unusual opportunity for determining stresses that result from reservoir load alone but, as this is written, sufficient data is not available for comment.

Details of location and arrangement of the instruments for this program were worked out by Paul Hornby, civil engineer, under direction of Ross M. Riegel, head civil engineer of TVA's technical staff. Experience developed on similar programs at Norris and Hiwassee has been invaluable in guiding the work at Fontana. Credit is due Douglas McHenry (now with the Bureau of Reclamation) for valuable data developed on the previous programs.

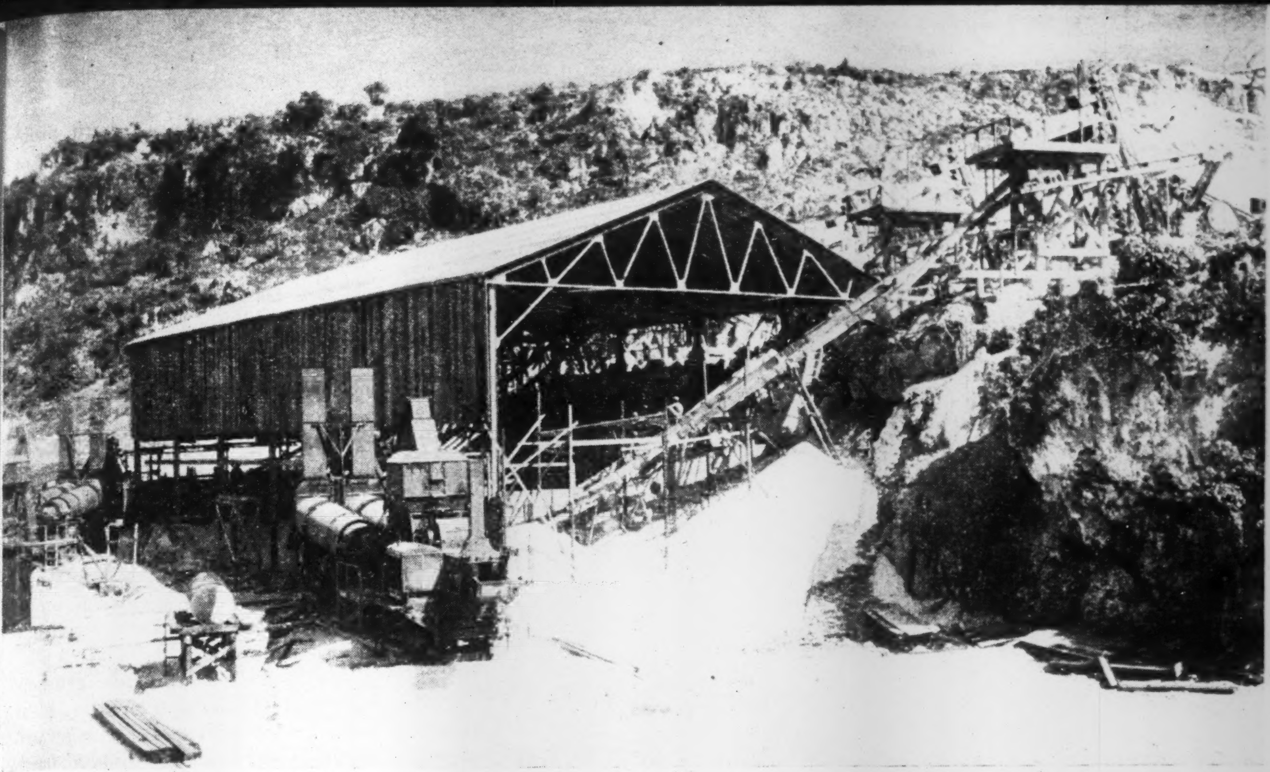


Fig. 1. Rock crushers and asphalt plant were built into the side of the mountain that served as the aggregate supply.

Asphalt Plant for an Island Airbase

Alexander Keirsey

Storekeeper, Third Class, U. S. Naval Reserve, Sixth Construction Battalion, U. S. Navy

Contents in Brief—*Five portable rock crushing plants were set up as a battery in a mountainside to process hard coral, which was delivered by gravity to the asphalt plant. Bitumen in 55-gal. drums was delivered over a tank where it was heated on a steam coil "pancake".*

AMONG THE MANY CONSTRUCTION jobs that faced Navy Seabees and their Civil Engineer Corps officers when they came ashore in the wake of assault troops at Tinian was to provide facilities for the Army's Superforts. Important among these was the assembling, from what material was at hand, of an asphalt plant for paving the airfield.

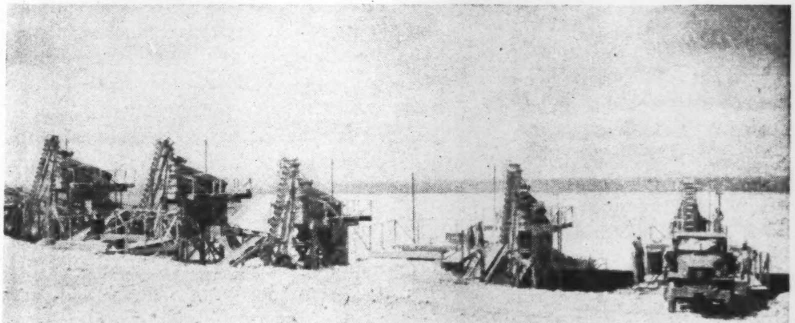


Fig. 2. Five semi-mobile rock crushers were set up in a row just above the asphalt plant.

Ordinarily, the construction of an asphalt plant is no great job; but out near the end of the long Pacific supply lines many problems arose. However, a modern asphalt plant was built, designed to provide a continuous flow of aggregate with no handling from the time the rock is dumped into the crusher hoppers until the finished product spills from the mixer into the distributing trucks.

A site for the plant was chosen at the abrupt termination of a mountain. Here the naturally tiered elevations provided an almost perfect location for the various units of the plant. Accessibility to an improved road system, and the proximity of the plant site to the project were important, of course.

Available was an almost unlimited source of aggregate from a coral outcropping having a large percentage of

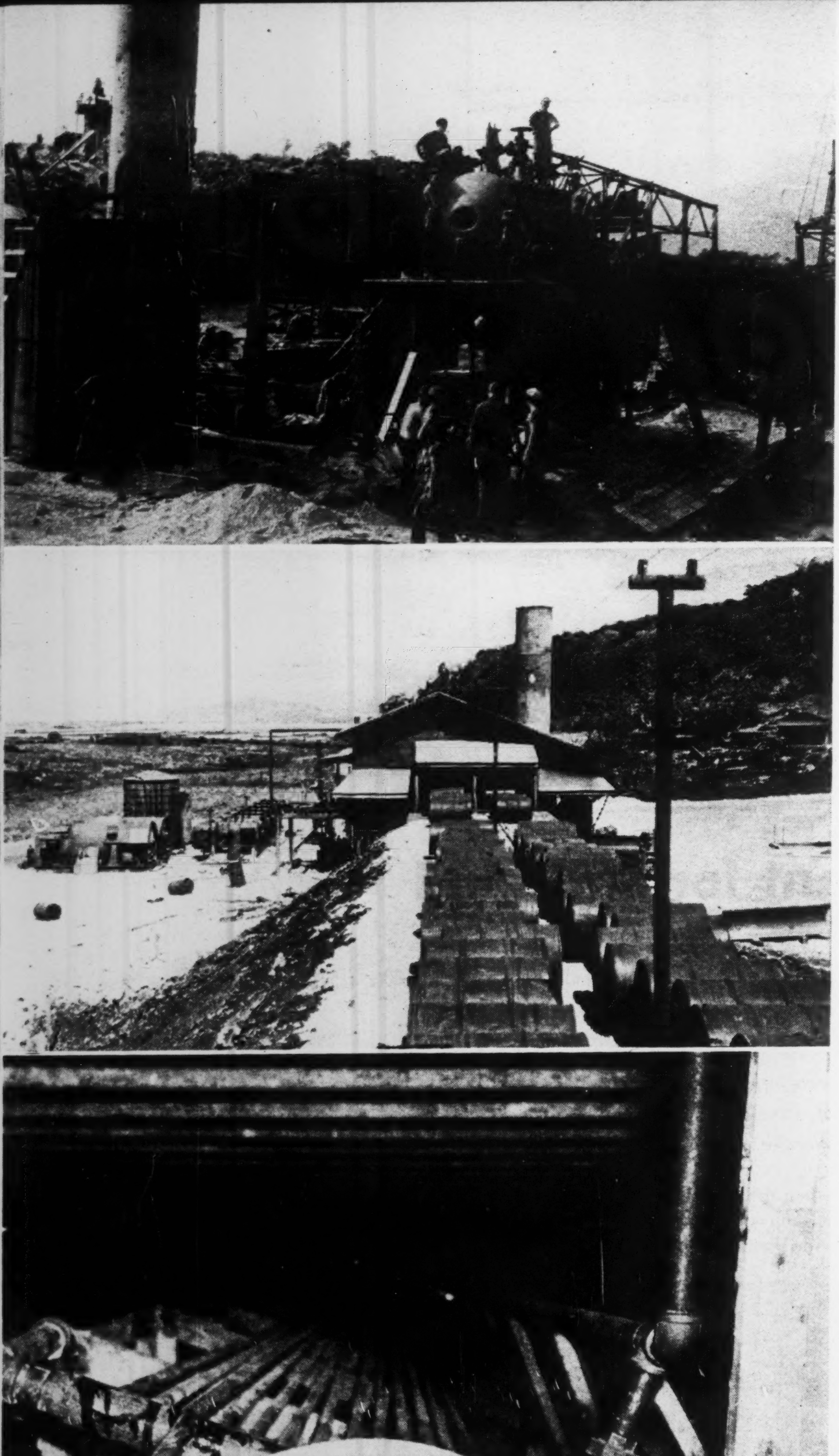


Fig. 3. A water-tube boiler from a wrecked Japanese sugar mill (top) supplied steam for heating bitumen, which was received in barrels. Drums of bitumen were rolled on rails to a shed (center) and then over steam coils (bottom) that heated the material so it fell into the tank below.

limestone. The coral was hard, probably formed by a combination of weathering and forces induced by earthquake, and unlike the soft coral sought by service engineers for the surfacing of airstrips.

Five crushers set above plant

Some thirty feet above the asphalt plant five rock crushers of a semi-mobile type were set up in parallel position on a leveled shelf. Each of the machines was equipped with a primary jaw 36 x 18 in.; a 30 x 18 roller serving as a secondary crusher. Shaker screens divided the material from the crushers into two sizes of aggregate—minus $\frac{3}{4}$ in. and minus $\frac{3}{8}$ in. This size was selected in an effort to obtain a dense, theoretically graded aggregate.

The product of the five crushers moved by gravity to the mixing plant below. The aggregate was separated at the lower level by divider partitions 12 to 15 ft. in height and 50 ft. long. A cross bulkhead at the end of the divider partitions retained the aggregate in the stock pile. An effort was made to maintain a stock pile of 1,000 tons for each of the two sections of the plant. The aggregate was protected from the weather by a roof made of salvaged enemy materials so that dry stock was available at all times.

Two multiple aggregate, central asphalt plants were installed, capable of providing from $1\frac{1}{2}$ to 2 cu. yd. of bituminous material each minute. When in operation, the two plants consume some 2,300 gal. of 70 penetration asphalt cement an hour.

Bitumen in 55-gal. drums

The plants were constructed for use with tank cars or other reservoirs as a source of asphalt cement. But the only supply available at this base came in 55-gal. steel drums. To obtain a flow of bitumen, which would allow the plant to operate at anywhere near capacity, it was necessary to improvise an efficient method of emptying the asphalt shipping drums. Small steam-jennies of 42-boiler hp. supplied with the mixing plants, while excellent for the task under ordinary circumstances, fell far short of a capacity necessary to heat the large quantity of bitumen required, provide mixing temperatures to the mixers, and supply steam for the oil burners on the aggregate driers.

In the battle wreckage of a Japanese sugar mill was found a large watertube boiler, capable of supplying 200-boiler hp. at a pressure of 125 psi. Despite the many high explosive shells and other projectiles sent into the mill during the first days of the battle for the island, and flames that swept the structure during the height of hostilities, the boiler was still in relatively good condition. A Japanese-built heating furnace at the mill was wrecked to provide fire brick for lining the boiler. And a portion of the steel furnace shell was pressed into use as a flue stack on the main boiler. The small steam-jennies, supplied with the mixing plant, were set up for use as stand-bys for the larger boiler.

Emptying 55-gal. drum

With the acquisition and installation of the Japanese-manufactured boiler, the problem of obtaining sufficient steam was solved. Next it was found necessary to devise a method of supplying that steam to the bitumen filled drums.

A steel tank, 18 ft. square and 5 ft. deep was fabricated. It was lined with steam coils and a steam "pancake." Two tracks of steam pipe, gauged to support the steel drums, were fixed across the top of the tank. These two tracks were fashioned so that the heated bitumen spills readily into the tank below and each track over the top of the tank supported ten drums. The contents of two drums were emptied into the tank every 1⅓ min.

The tracks of steam pipe over the tank were connected with steel rails, leading from the heating house to the nearby dump of bitumen filled steel drums. Along this improvised line, which was built of rails and ties recovered from the rail line formerly used by the enemy to haul sugar cane from the fields to the sugar mill, the bitumen was moved into the heating house as needed. This structure, made of brick, had openings only for the entrance and exit of the containers. Thus, all possible heat was utilized for heating the bitumen.

Once in the heating-house tank, the bitumen was brought up to pumping temperature by the steam coils and the steam "pancake" built into the container. After this preliminary heat treatment, the bitumen was pumped into six nearby tanks. Four of these tanks—about 4,000-gal. capacity each—were seized by Navy engineers when discovered in the wreckage of the Japanese mill. The latter tanks, fortunately, were already fitted with steam coils.

Bitumen drawn by metering pumps

While the bitumen was in these six tanks, heat was again applied until a temperature of 300 deg. F. was obtained. As needed, the bitumen was drawn from the tanks by metering pumps on the mixers and sprayed upon the aggregate in the mixer pug mill. And then the mixed product was spilled into trucks for transportation to the project.

Lieut. (j.g.) Elbert J. Tate, (CEC) USNR of Santa Paula, Calif., served as resident engineer on the asphalt plant installation. Lieutenant Edward T. Barry, Jr., (CEC), USNR, of Laurelton, New York, a former highway contractor, was in charge of operations.

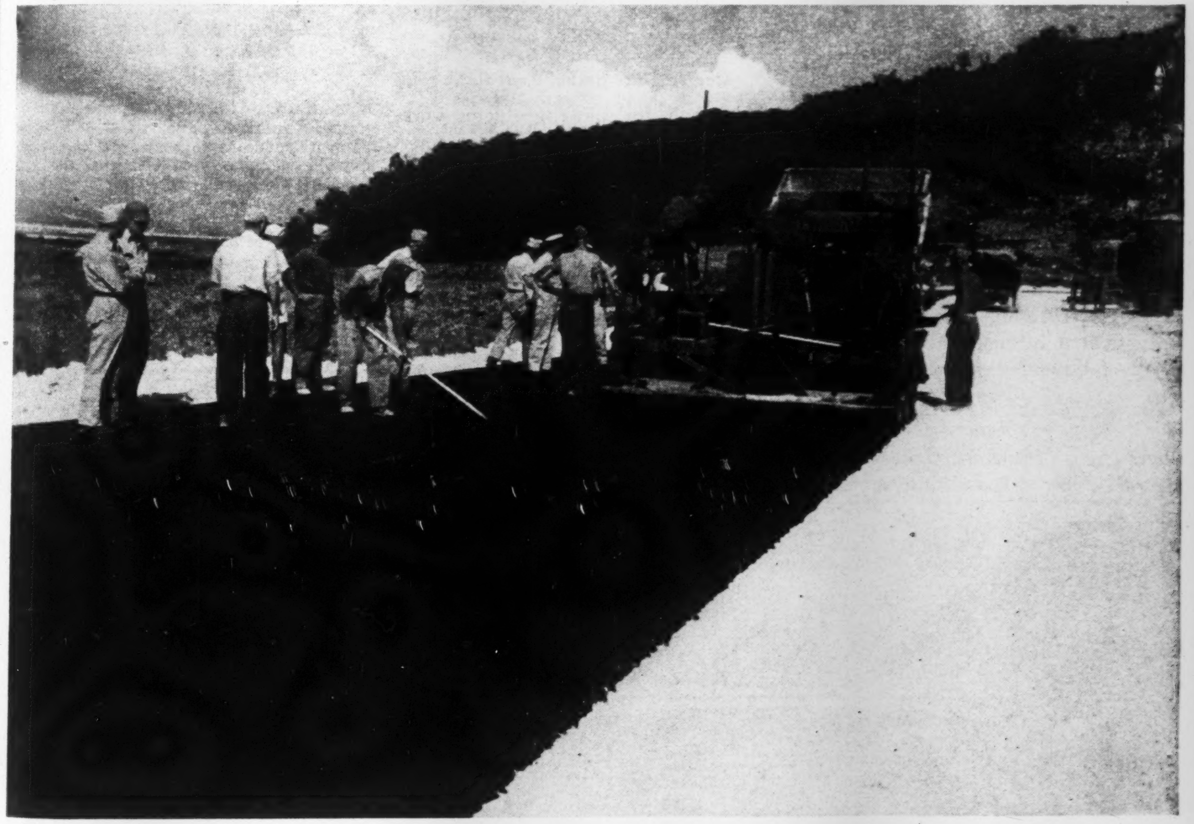


Fig. 5. Asphaltic surfacing material being laid over coral service roads near the site of the asphalt plant.

Moment Ratios Simplify Continuity Analysis—Part II

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Contents in Brief*—Concluding the explanation of the use of moment ratios in computing maximum bending moments in continuous structures that was initiated in ENR Nov. 1, 1945, vol. p. 604, formulas for end moments in terms of actual restraint are given, and using these formulas, a technique for solving problems involving moving loads is developed. A convenient method of analyzing rigid frames subject to sidesway is also illustrated.*

ANALYSIS of continuous structures using the method of moment ratios, as indicated in the building frame in Part I, consists of computing the stiffness S at each end of a member, determining restraint R as the sum of stiffnesses, calculating moment ratios C and distributing fixed-end moments.

Stiffnesses and moment ratios are structural constants independent of loads. They are conveniently expressed in terms of end rotations caused by a moment of unity applied to the ends of a simply supported unit beam. α is the rotation at the end where the moment is applied and β the rotation at the other end. To obtain end rotations in the prototype, α and β must be multiplied by ML/EI.

For convenience, the expression $EI/\beta L$ is represented by K. Then, stiffness at A in member AB is given by the following expression:

$$S_{AB} = \frac{K_{AB}}{\alpha_{AB}/\beta_{AB} - 1/C_{AB}},$$

where C_{AB} is defined as moment ratio, M_{AB}/M_{BA}, for transmitting moment from A to B. Moment ratios are computed from the following equation:

$$C_{AB} = \frac{\alpha_{AB}}{\beta_{AB}} + \frac{K_{AB}}{R_{BA}},$$

where the restraint R is the sum of the stiffnesses of the restraining members at end B. At a joint, unbalanced moments, such as those occurring when fixed-end moments are used, are distributed in proportion to the stiffnesses of the members of the joint.

Moments for actual restraint

Although for most problems end moments due to loads may be conveniently expressed before distribution as fixed-end moments, there are occasions when end moments are more useful if expressed in terms of actual restraint. For this purpose moment ratios are ideal.

The three loaded spans in Fig. 1 will be used to derive a general expression for end moments in terms of the moment ratios. Let $C'_{BA} = M_{BA}/M_{AB}$, $C'_{CD} = M_{CD}/M_{DC}$ and ϕ with the proper subscript = the simple beam end rotation due to load on the span. Equating the expressions for angular rotation on either side of joint B, putting $M_{BA} = -M_{BC}$, and noting that in the resulting equation the coefficient of M_{BC} is C_{CB}, then,

$$C_{CB}M_{BC} - M_{CB} = -(\phi_{BC} - \phi_{BA})K_2.$$

Similarly,

$$C_{BC}M_{CB} - M_{BC} = (\phi_{CD} - \phi_{CB})K_2.$$

Solving for M_{BC} and M_{CB},

$$M_{BC} = -\frac{K_2[C_{BC}(\phi_{BC} - \phi_{BA}) + (\phi_{CB} - \phi_{CD})]}{C_{BC}C_{CB} - 1};$$

$$M_{CB} = -\frac{K_2[C_{CB}(\phi_{CB} - \phi_{CD}) + (\phi_{BC} - \phi_{BA})]}{C_{BC}C_{CB} - 1}.$$

Example 1—As an example of the use of the generalized moment equations, consider Fig. 2 with all four spans loaded, producing the following simple beam end rotations: at AB = + 500/K_{AB}, at BA = − 500/K_{AB}, at DC = − 500/K_{DC}, at CD = + 500/K_{DC}, at AD = − 1,000/K_{AD}, at DA = + 1,000/K_{AD}, at BC = + 250/K_{BC}, and at CB = − 250/K_{BC}. By applying the generalized moment equations to span AB, the frame may be completely solved for the end moments without the necessity of unloaded beam distribution, since $C'_{AD} = C'_{DA} = C'_{BC} = C'_{CB} = -1$. As in **Ex. 3**, Part I $C_{BA} = C_{CD} = 3.5$ and $C_{AB} = C_{DC} = 6.5$.

$$\phi_{AB} - \phi_{AD} = 500/3 - (-1{,}000/6) = 333;$$
$$\phi_{BA} - \phi_{BC} = -500/3 - 250/2 = -292;$$

$$M_{AB} = -3 \times \frac{6.5 \times 333 - 292}{6.5 \times 3.5 - 1} = -258 = -M_{DC};$$

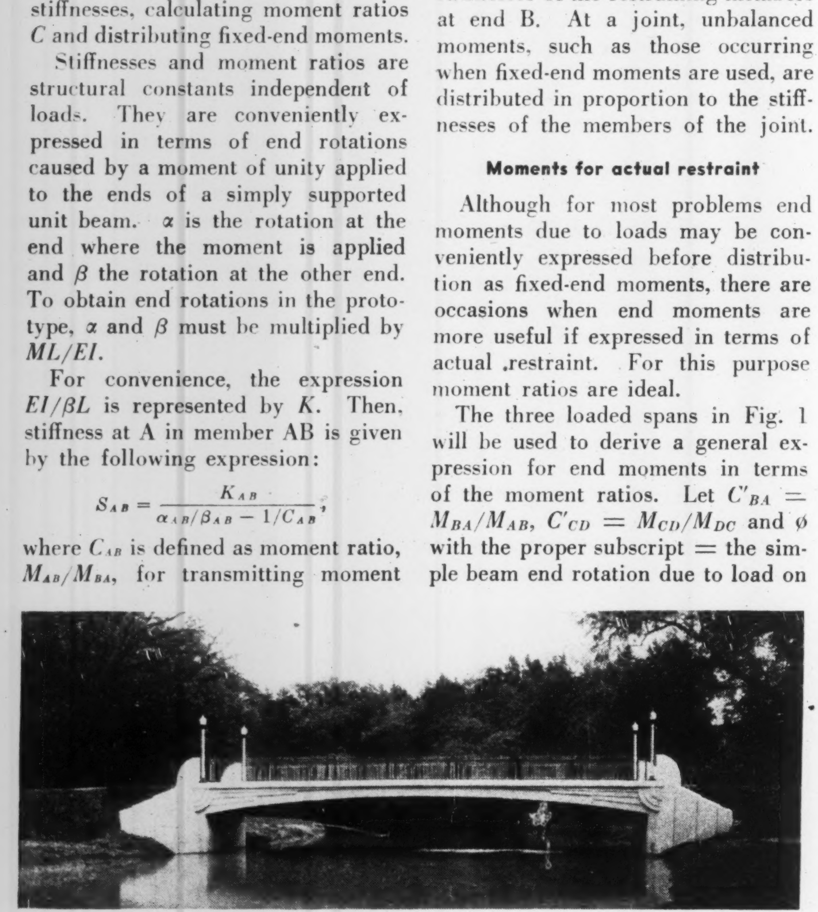
$$M_{BA} = -3 \times \frac{-3.5 \times 292 + 333}{6.5 \times 3.5 - 1} = +95 = -M_{CD}.$$

Although the generalized moment equations have many interesting possibilities for use in short-cut methods, as indicated in Example 1, the special case in which only one span is loaded is more valuable. The contracted form, referred to hereafter as the end moment formulas, is:

$$M_L = -\frac{K(C_R\phi_L + \phi_R)}{C_RC_L - 1};$$

$$M_R = -\frac{K(C_L\phi_R + \phi_L)}{C_RC_L - 1}.$$

Fixed-end moments may be obtained from the end moment formulas by setting the moment ratios C =



Rigid frame bridges may be analyzed by moment distribution using moment ratios.

$C^r = \alpha/\beta$. The end moment formulas may also be used for plotting influence lines. By varying the position of the load on the span, computing the corresponding simple beam end rotations and substituting in these equations, the influence moment curve is obtained, and from this can be determined the location of loads for maximum moment.

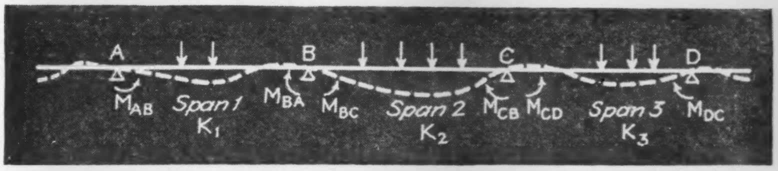


Fig. 1. Generalized end moment equations are determined for span BC of this unequally loaded continuous beam.

Rotations for variable I

For beams of constant I the influence equation for end moment can be written directly from the end moment formulas, since the simple beam end rotations also can be expressed by formulas. Where variable I is involved, the problem is more complex; seldom, if ever, will the end rotations be expressible in formula form.

However, by using Tables I and II, problems concerning beams of variable I can be simplified. Table I contains factors to be used in computing α and β and Table II contains influence factors for $E\phi/L$. For purposes of both tables the span has been divided into ten parts, each to be considered of constant I, and the contribution of each of the parts to the end rotation entered. If I_x is the moment of inertia at the center of each of these parts taken in turn, then, the final end rotation factor is obtained by dividing the factor for each of the parts by I_x and summing, and in addition for Table I by multiplying the summation by I, the least moment of inertia. To conserve space Table II gives only the values for the rotation at the end from which the parts are numbered and the factors have been multiplied by 100,000. On the other hand in Table I the unit beam parts have been numbered from the end at which α_L is measured and the actual values entered.

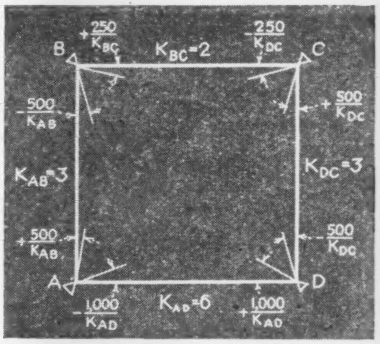


Fig. 2. Simple beam end rotations caused by loads on the closed frame of Fig. 4 (Part I) are as shown. Because of symmetry, end moments may be obtained directly from the generalized moment formulas.

Except for the last column, which contains factors for uniform load, Table II consists of factors for the end rotations due to a unit load at the tenth points. To obtain the actual end slope, it should be remembered that not only must each part be divided by I_x, but the summation of the quotients must be multiplied by the actual value of the load and span length and divided by $100{,}000E$. Similarly, the quantities in the last column must be multiplied by the total load and span length and divided by $100{,}000E$.

Moments for constant I

As stated previously, for beams of constant I the influence equation for end moment can be written directly from the end moment formulas for variable I. It can be shown that

$$\phi_L = a\,(1-a)\,(2-a)\,\frac{PL}{K}\,;$$

$$\phi_R = -\,a\,(1-a)\,(1+a)\,\frac{PL}{K}\,,$$

where P is a concentrated load at a distance aL from the left support of a span of length L. Therefore,

$$M_L = -\,\frac{a\,(1-a)\,[C_R\,(2-a)-(1+a)]}{C_RC_L-1}\,PL;$$

$$M_R = +\,\frac{a\,(1-a)\,[C_L\,(1+a)-(2-a)]}{C_RC_L-1}\,PL.$$

These equations may be generalized to give the end moments due to any load mass by letting aL be the distance from the left support to the center of gravity of the mass and referring individual components to the center of gravity, taking distances to the right as positive and to the left as negative. Let b_nL be the dis-

TABLE I—FACTORS FOR UNIT BEAM ROTATIONS

Part* No.	α_L	α_R	β
1	0.0904	0.0003	0.0047
2	0.0724	0.0023	0.0127
3	0.0564	0.0063	0.0187
4	0.0423	0.0123	0.0226
5	0.0303	0.0203	0.0246
6	0.0203	0.0303	0.0246
7	0.0123	0.0423	0.0226
8	0.0063	0.0564	0.0187
9	0.0023	0.0724	0.0127
10	0.0003	0.0904	0.0047
Σ	0.3333	0.3333	0.1666

*Parts are numbered from end at which α_L is measured.

TABLE II—INFLUENCE FACTORS FOR $E\,\Phi/L \times 10^5$*

Part No.	Position of Unit Load* 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Uniform Load
1	420	373	327	280	233	187	140	93	47	218
2	724	1013	887	760	633	507	380	253	127	535
3	564	1126	1306	1120	933	747	560	373	187	698
4	424	846	1270	1360	1133	907	680	453	226	736
5	303	607	910	1214	1233	986	740	494	246	678
6	203	407	610	814	1017	986	740	494	246	555
7	123	247	370	493	617	740	680	453	227	398
8	63	127	190	253	317	380	444	373	187	235
9	23	47	70	93	117	140	163	187	127	98
10	3	7	10	13	17	20	23	27	30	16
Σ	2850	4800	5950	6400	6250	5600	4550	3200	1650	4167

*Rotation is given for and position of load is measured from end from which parts are numbered.

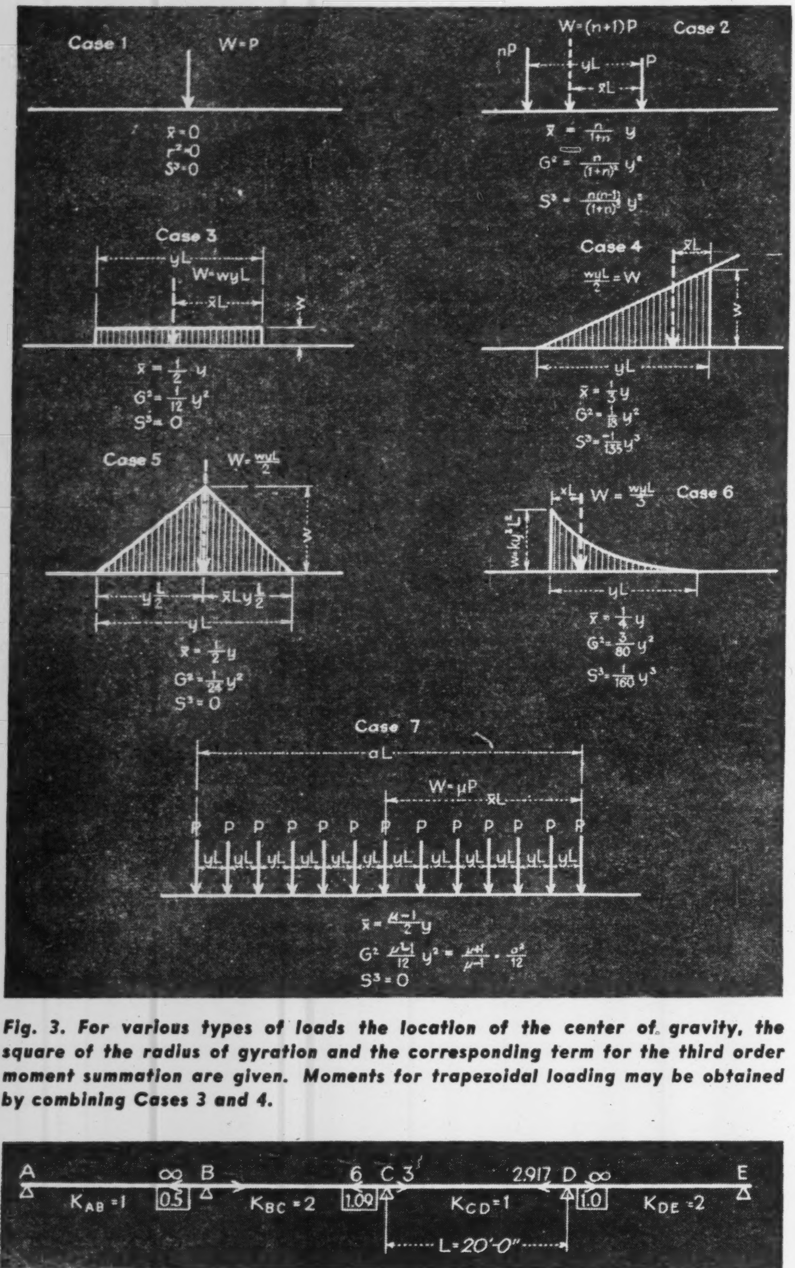

Case 1
W=P
x̄=0
r²=0
S³=0
W=(n+1)P
Case 2
nP
yL
P
x̄L
x̄ = n/(1+n) y
G² = n/(1+n)² y²
S³ = n(n-1)/(1+n)³ y³
Case 3
yL
W=wyL
x̄L
w
x̄ = 1/2 y
G² = 1/12 y²
S³ = 0
Case 4
wyL/2 = W
x̄L
w
yL
x̄ = 1/3 y
G² = 1/18 y²
S³ = -1/135 y³
Case 5
W = wyL/2
w
y L/2
x̄Ly L/2
yL
x̄ = 1/2 y
G² = 1/24 y²
S³ = 0
xL
W = wyL/3
Case 6
w=ky³L³
yL
x̄ = 1/4 y
G² = 3/80 y²
S³ = 1/160 y³
Case 7
aL
W=μP
x̄L
P P P P P P P P P P P P P
yL yL yL yL yL yL yL yL yL yL yL yL
x̄ = (μ-1)/2 y
G² (μ²-1)/12 y² = (μ+1)/(μ-1) · a²/12
S³ = 0

Fig. 3. For various types of loads the location of the center of gravity, the square of the radius of gyration and the corresponding term for the third order moment summation are given. Moments for trapezoidal loading may be obtained by combining Cases 3 and 4.

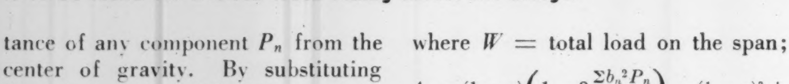

A
∞
B
6
C
3
2.917
D
∞
E
K_AB =1
0.5
K_BC =2
1.09
K_CD=1
1.0
K_DE =2
L=20'-0"

Fig. 4. By means of moment ratios the maximum end moments produced by moving loads may be determined. In the case illustrated above, the end moment at C in CD is to be found for a 6-ton truck rolling across the bridge.

tance of any component P_n from the center of gravity. By substituting $(a + b_n)$ for a and P_n for P in these equations and noting that according to the definition of center of gravity $\Sigma b_n P_n = 0$, we obtain the general expressions:

$$M_L = -\frac{C_R A_L - A_R}{C_R C_L - 1} WL;$$

$$M_R = +\frac{C_L A_R - A_L}{C_R C_L - 1} WL;$$

where W = total load on the span;

$$A_L = (1-a)\left(1 - 3\frac{\Sigma b_n{}^2 P_n}{W}\right) - (1-a)^3 + \frac{\Sigma b_n{}^3 P_n}{W};$$

$$A_R = a\left(1 - 3\frac{\Sigma b_n{}^2 P_n}{W}\right) - a^3 - \frac{\Sigma b_n{}^3 P_n}{W}.$$

These general expressions involve terms of some philosophical interest. For instance, $\Sigma b_n{}^2 P_n$ is the moment of inertia of the load mass about its center of gravity and $\frac{\Sigma b_n{}^2 P_n}{W}$ may therefore be set equal to G^2, the square of the radius of gyration. Similarly, $\Sigma b_n{}^3 P_n$ is a third order moment summation, which has the property of vanishing for symmetrical masses. Setting $\frac{\Sigma b_n{}^3 P_n}{W} = S^3$, the above expressions become:

$$A_L = (1-a)(1-3G^2) - (1-a)^3 + S^3;$$
$$A_R = a(1-3G^2) - a^3 - S^3.$$

S^3 appears with a plus sign in the expression for M_L and with a minus sign in the expression for M_R. By rotating a load mass one hundred eighty degrees about its center of gravity, S^3 changes sign, whereas G^2 and a remain unchanged. Therefore, S^3 is the criterion for determining which way a moving load mass should be turned to produce maximum end moment.

In Fig. 3 are tabulated for various types of loads the location of the center of gravity of the load mass, the square of the radius of gyration and the corresponding term for the third order moment summation. When these values are substituted in the general expressions for constant I, end moment formulas for the various types of loads are obtained. Fixed-end moments can always be obtained from them by setting the moment ratios equal to 2.

Maximum moments for moving load

When differentiated and set equal to zero, the end moment formulas yield the location of a load mass to produce maximum end moment. This is illustrated in Example 2.

Example 2—A truck having a 4.5 kip rear wheel load and a 1.5 kip front wheel load, 10 ft. apart, is traveling across the four-span, prismatic, continuous beam bridge shown in Fig. 4. Assume that the slab transmits 1.333 times a wheel load to the beam. What is the maximum moment produced in the 20-ft. span CD at C?

The necessary moment ratios are computed first, noting that ends A and E are pinned, making C_{BA} and C_{DE} infinitely large. $R_{DC} = S_{DE} = 2/(2-0) = 1$ and $C_{CD} = 2 + 1/1 = 3$. $R_{BC} = S_{BA} = 1/(2-0) = 0.5$ and $C_{CB} = 2 + 2/0.5 = 6$. $R_{CD} = S_{CB} = 2/(2 - 1/6) = 1.09$ and $C_{DC} = 2 + 1/1.09 = 2.917$. The moment ratios are shown in Fig. 4 above the arrows on the spans and the stiffnesses in boxes under the spans.

The center of gravity of the load is located $6 \times 10/(6+2) = 7.5$ ft. from the front wheel.

$$G^2 = \frac{6\,(2.5)^2 + 2\,(7.5)^2}{8\,(20)^2} = 0.0469.$$

To compute S^3 assume that the truck is moving toward D.

$$S^3 = \frac{-6\,(2.5)^3 + 2\,(7.5)^3}{8\,(20)^3} = +0.0117.$$

Since S^3 is positive and has a plus sign before it in the expression for moment at the left end, the load is turned in the proper direction to produce maximum moment.

$$A_L = (1 - a)(1 - 3 \times 0.0469) - (1 - a)^3 + 0.0117$$
$$= 2.141a - 3a^2 + a^3 - 0.1290;$$
$$A_R = a(1 - 3 \times 0.0469) - a^3 - 0.0117$$
$$= 0.859a - a^3 - 0.0117$$
$$dA_L/da = 2.141 - 6a + 3a^2;$$
$$dA_R/da = 0.859 - 3a^2.$$

Setting

$$C_R\, dA_L/da - dA_R/da = 0,$$

we have

$$3(2.141 - 6a + 3a^2) - 0.859 + 3a^2 = 0;$$

or $a(1.5 - a) = 0.463$. Solving on the slide rule, $a = 0.435$.

Hence, $A_L = 0.315$ and A_R 0.279. Therefore, maximum

$$M_{CD} = -\frac{3 \times 0.315 - 0.279}{3 \times 2.917 - 1} \times 8 \times 20$$
$$= -13.8 \text{ ft. kips.}$$

Using Fig. 5, the location of the truck could also have been found. In this chart the intersection of the horizontal lines representing values of C with the almost vertical curves representing G^2 determines a for maximum end moment. In this case the intersection of $C_R = 3$ with $G^2 = 0.047$ yields $a = 0.44$.

Fixed-end moments can also be obtained from Fig. 5. After the intersection of the vertical a-line with a lower G^2 curve is found, a horizontal line is drawn through this point until it meets the proper S^3 diagonal. The horizontal ordinate at this intersection represents a constant, which, when multiplied by the total load and span length, gives the required moment. Locating a load for maximum moment and obtaining the corresponding fixed-end moments can thus be performed in one step, as illustrated by the dotted line in Fig. 5.

When the end moments are known, the structure becomes statically determinate. Positive moments may be determined from the end moments. Also, general expressions similar to those for end moments may be obtained for positive moments; they may be differentiated and equated to zero and maximum positive moments calculated. But these general equations are too cumbersome for practical use. However, the procedure is simple and with practice in the method the designer will discover many short-cuts.

Support deflection moments

Up to now, the effect of sidesway, the deflection of joints under load, has been ignored. This problem can be solved when the effect of a linear movement of a support on end moments is known.

The end rotations of a simply-supported column in which, say, the top support shifts to the right of the bottom support, are $+d/L$, where d is the amount of sway and L is the length of column. Substituting this in the end moment formulas, the moments in a restrained column are obtained.

$$M_L = -\frac{C_R + 1}{C_R C_L - 1}\,\frac{Kd}{L};$$
$$M_R = -\frac{C_L + 1}{C_R C_L - 1}\,\frac{Kd}{L}.$$

According to these formulas, the ratio between fixed-end moments due to

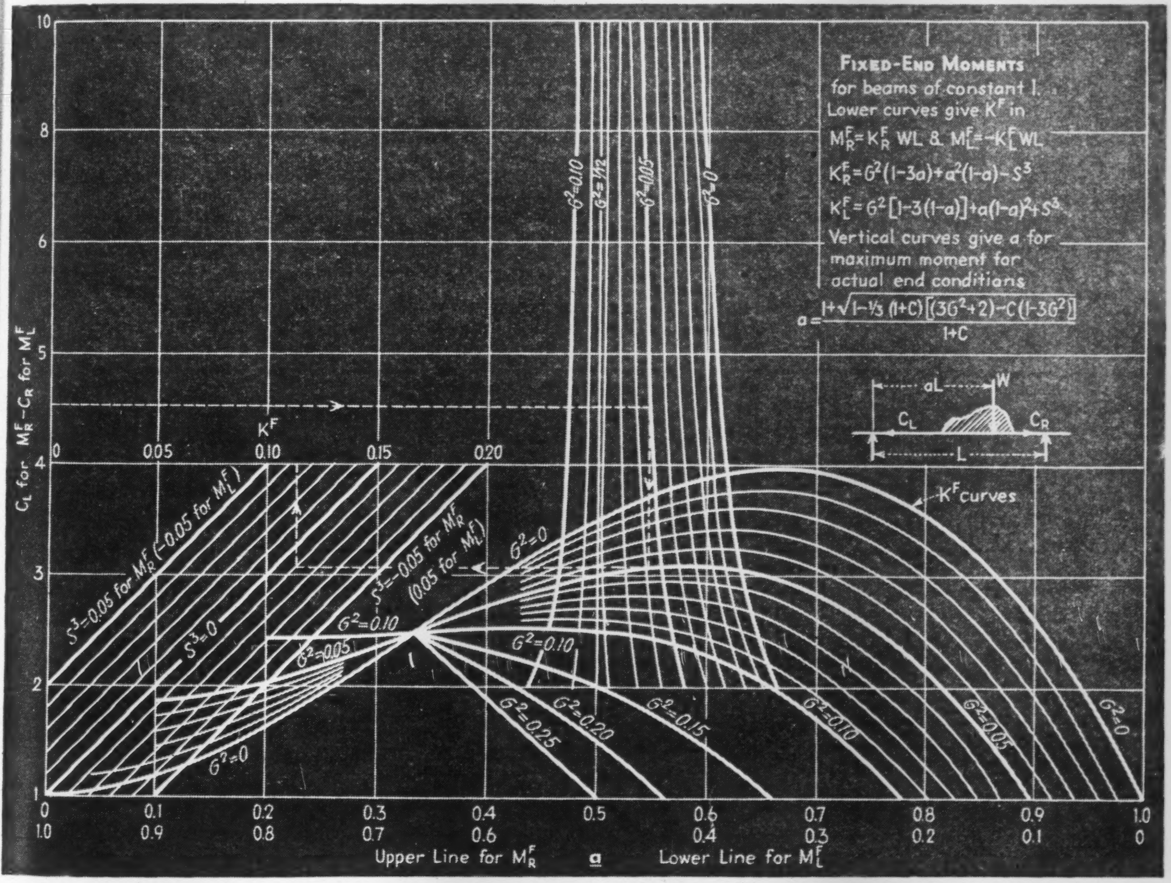


Fig. 5. In one step, using the above chart, the location of a load mass to produce maximum end moment in a span of constant moment of inertia and the corresponding fixed-end moment may be found. The vertical curves determine the location of the resultant of the load for maximum moment. As illustrated by the dotted line, after the load has been located, a constant is obtained, which, when multiplied by the total load and the span length, yields the end moment.

sidesway at the top and bottom of a column is $M_L/M_R = (C_R^F + 1)/(C_L^F + 1)$. For symmetrical columns $C_R^F = C_L^F$, and the ratio equals unity. Also, in prismatic columns the fixed-end moments are $-Kd/L$. That is, fixed-end moments in prismatic columns subject to sidesway are proportional to their K-values and amounts of sidesway and in addition are inversely proportional to their lengths.

Procedure for sidesway

The problem of sidesway in rigid-frames is conveniently solved by the following method:

1. Apply forces to the structure to prevent sidesway while the fixed-end moments due to loads are distributed.
2. Compute the moments due to these forces.
3. Combine the moments obtained in Steps 1 and 2 to eliminate the effect of the forces.

Examples 3 and 4 are an illustration of the method to be employed and also give a general procedure for the solution of indeterminate structures.

Example 3—Compute the end moments in the members of the rigid-frame shown in Fig. 6 due to a 2,000 lb. horizontal load applied at the level of beam BC.

Since A and D are fixed, $C_{BA} = C_{CD} = 2$. $R_{BC} = S_{BA} = 6/(2 - 1/2) = 4$; $C_{CB} = 2 + 3/4 = 2.75$; and $S_{CB} = 3/(2 - 1/2.75) = 1.83$. $R_{CB} = S_{CD} = 2/(2 - 1/2) = 1.33$; $C_{BC} = 2 + 3/1.33 = 4.25$; and $S_{BC} = 3/(2 - 1/4.25) = 1.70$. Torques of + 1,000 are applied at joints *B* and *C*, respectively, and the results of the distributions collected in a Moment Influence Table (Table III).

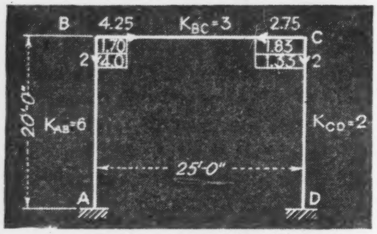


Fig. 6. Rigid frame problems generally involve sidesway. To illustrate the application of moment ratios to these problems the above frame is used.

TABLE III—MOMENT INFLUENCE FACTORS

Member	+1,000 at B	+1,000 at C
AB	351	−105
BA	702	−210
BC	298	210
CB	70	579
CD	−70	421
DC	−35	210

Assume due to sidesway a fixed-end moment of $-1{,}000M$ at the top and bottom of column CD. Since the movement at the top of column BA is the same as that at the top of CD and the columns are of equal length, the fixed-end moments vary as their K-values. Therefore, a fixed-end moment of $-1{,}000 \times 6/2 = -3{,}000M$ must also be assumed at the top and bottom of AB. The distribution of these moments is performed by means of Table III and the results collected in a Moment Collection Table (Table IV).

For example, the total unbalance at joint B is $-3{,}000M$ and hence, $+3{,}000M$ must be distributed. The distribution is performed by merely multiplying by $3M$ the values in the column of the Moment Influence Table marked "+ 1,000 at B," and the products are entered in the row in the Moment Collection Table labeled "Sidesway—Distribution—B."

The sum of the end moments in the columns equals $-M(2{,}052 + 1{,}104 + 789 + 895) = -4{,}840M$. This is the resistance offered to the overturning moment $2{,}000 \times 20 = 40{,}000$. Therefore, $M = 40{,}000/4{,}840 = 8.26$. Multiplying the Sidesway Totals in Table V by this value, we obtain the end moments due to the 2,000 lb. horizontal load.

Practical value of method

Once the Moment Influence Table and the sidesway moments in terms of M have been calculated, very little extra work is required to evaluate the effect of loads on the structure. (See Example 4). This is of practical importance, because the designer of a rigid-frame bridge wants to know the separate moments due to dead load, live load, side pressure and other conditions, so that he may combine them to produce the worst condition at any section of the structure.

Example 4—A vertical load of 4,000 lb. is applied to span BC of the rigid-frame in Fig. 6, 5 ft. from B. Compute the end moments.

Using $a = 5/25 = 0.2$, the fixed-end moments in span BC are: $M_{BC} = -a(1 - a)^2\,PL = -0.2\,(0.8)^2 \times 4{,}000 \times 25 = -12{,}800$ ft. lb. $M_{BC} = a^2\,(1 - a)\,PL = (0.2)^2 \times 0.8 \times 4{,}000 \times 25 = 3{,}200$ ft. lb. The Moment Influence Table of Example 3 is used for the distribution. For example, for the unbalanced moment of − 12,800 at B, multiply the values for "+ 1,000 at joint B" by + 12.8. Enter in the Moment Collection Table (Table IV).

The effect of sidesway due to the 4,000 lb. vertical load is determined from the following equation involving the sum of the end moments in the column:

$-4{,}840M + 4{,}826 + 9{,}652 - 2{,}244 - 1{,}120 = 0$; $M = 2.30$. Multiplying the Sidesway Totals in Table IV, by this value, we obtain the sidesway effect of the 4,000 lb. toad, and the addition of these moments to the totals for no sidesway yields the final moments.

TABLE IV—MOMENT COLLECTION TABLE

Remarks	AB		BA		BC		CB		CD		DC	
	+	−	+	−	+	−	+	−	+	−	+	−
Sidesway—F.E.M.		3000M		3000M						1000M		1000M
do —Distrib.—B	1053M		2106M		894M		210M			210M		105M
do — do —C		105M		210M	210M		579M		421M		210M	
Partial Totals	1053M	3105M	2106M	3210M	1104M		789M		421M	1210M	210M	1105M
Totals		2052M		1104M	1104M		789M			789M		895M
For 2000# Horiz. Load		17,000		9100	9100		6500			6500		7400
4000# Load—F.E.M.						12,800	3200					
do —Distrib.—B	4490		8980		3820		897			897		448
do — do —C	336		672			672		1853		1347		672
Partial Totals	4826		9652		3820	13,472	4097	1853		2244		1120
No Sidesway—Totals	4826		9652			9652	2244			2244		1120
Sidesway—4000# Load		4710		2540	2540		1810			1810		2060
Totals	120		7110			7110	4050			4050		3180

Nuisance-Free Refuse Incineration Depends Largely on Proper Operation

Operating experiences of New York-New Jersey municipal engineers also reveal that costs may have wide variation, especially in small communities.

No COMMUNITY need be concerned about odor, smoke or dust nuisance from a refuse incinerator provided the plant is properly designed and operated. This was the opinion of a panel of municipal engineers who discussed current operating practices before a recent meeting of the New York—New Jersey metropolitan chapter of the American Public Works Association.

The panel discussion on refuse incineration, which was one of a series on municipal activities sponsored by this organization, brought together Eugene Cranch, director of public service, New Rochelle, N. Y., who acted as moderator, Fred Bickmeyer, Garden City, L. I., Robert D. Woodcock of Rockville Centre, L. I., and G. Russell Hartley, engineer of Englewood, N. J.

In all frankness, asked one engineer in the audience, can it be said that a refuse incinerator can be operated without odor, smoke and dust nuisance in a residential community. The four men comprising the panel answered yes, but it was pointed out that the plant must be designed in accordance with established engineering principles and properly operated—with special emphasis on the latter. The plant at Rockville Centre was said to be within 150 ft. of residences and no complaints had ever been registered. At Englewood, where the plant is located on a hillside, wind from one direction causes downdrafts with probable deposition of some fly ash emanating from the chimney; this conclusion was reached on the basis of an occasional complaint from a nearby automobile painting shop.

Objectional truck traffic

A real and justifiable objection to an incinerator plant located in a residential area, stated Joseph I. Frankel of the Nichols Engineering and Research Corp., N. Y., was the concentration of street traffic caused by the arrival and departure of collection trucks.

William Raisch, consulting engineer to the Borough of Queens, pointed out that New York City successfully operates a 750-ton incinerator on 57th St., which is in relatively close proximity to a hospital, a milk bottling plant as well as office building and apartment house areas.

People in Eastchester, N. Y., who built homes on a thoroughfare leading to that town's plant, raised no objection to the operation of the plant, reported Mr. Cranch, but they did petition the town council to change the name of the thoroughfare, which was Incinerator Road. A now unknown genius suggested Burnham Road, which was approved.

Variations in disposal cost

Some idea of the way costs may vary was revealed by New Rochelle's experience. In 1941 when the plant handled 20,862 tons of refuse, the operating costs (not including fixed charges) was $1.16 per ton, of which $0.96 represented labor alone. In 1944 the tonnage was 15,639, the operating cost $2.54, and labor alone was $1.60 per ton.

Garden City reported a $1.08 per ton operating cost and Englewood cited a $1.50 average. Rockville Centre, which handles about 12,000 tons a year, has a budget of $27,000; however, the plant salvages waste materials from which it gets an annual return of $15,000 and in addition may receive as much as $8,000 a year payment from other communities for burning their refuse. In this connection, Mr. Woodcock, the superintendent for the past 20 years, said that a charge of $3.75 per ton is made to other communities for burning service.

Another index of how costs of refuse-disposal service have gone up was revealed by Public Works Commissioner John J. McGowan of Elizabeth, N. J. A three year contract has just expired under which his city of 123,000 population received disposal service for $125,000 annually; the city has about 150 miles of streets and the average haul is 2¾ miles. Lowest bid on a new contract for identical service was $225,000, which the city is now considering.

Fred Galloway, town engineer of Montclair where refuse disposal is carried on by municipal forces, was asked if he thought the new bids received by Elizabeth were out of line. He said no. At Montclair, which has a population of 40,000, the yearly cost is about $130,000. The service provides two collections weekly with rear door pick-up. The latter feature, said Mr. Galloway, adds about 50 percent to labor costs (labor amounts to some $80,000 of the total budget of $130,000).

Waste heat utilization

What are the practical advantages and limitations to waste heat utilization for the generation of steam? This question was addressed to the incinerator manufacturers' representatives. Thomas J. Kelley, of the Morse Boulger Destructor Co., stated that generally it was not economical for a city to consider the generation of steam from an incinerator plant. Under special circumstances, where the close proximity of hospital buildings or some utility offer the opportunity to utilize the steam, there might be some justification for installing waste-heat recovery facilities. However, these additional facilities are costly.

Furthermore, said Mr. Kelley, steam generation called for 24-hour operation, and relatively few municipal incinerators are large enough to provide such service. His views were supported by Mr. Frankel of the Nichols Engineering and Research Corp.

These were some of the highlights of the panel discussion. Hardly any phase of incinerator operation was overlooked including even such matters as the quickest way to handle dead horses and the elimination of flies from the charging floor. Perhaps the only unanswered question was raised by Mr. Woodcock of Rockville Centre who wanted to know if there was any kind of chimney screen that would last more than a month. High temperatures and atmospheric changes produce such severe conditions that nothing to his knowledge—including monel metal, which he tried at great expense—had a service life of greater than 30 days.

U. S. Forest Products Laboratory at Madison, Wis., where great advances in timber research were made during the war.

Timber Products Research Secrets

Contents in Brief—*The U. S. Forest Products Laboratory recently revealed the latest technical developments resulting from timber-products research during the war and indicated possible peacetime applications. New materials include wood plastics, plywoods, "sandwich" construction and modified woods. Prefabricated house studies being resumed.*

THE WRAPS WERE TAKEN OFF the U. S. Forest Products Laboratory at Madison, Wis. on Oct. 11 and a complete demonstration given of heretofore secret wartime timber research. In a 7-hr. tour of the huge plant some 25 of the laboratory's scientists and technicians demonstrated a multitude of incredible advancements in forest products research to a group of technical editors and newspaper men.

Activities of the laboratory have been extended so widely under the impetus of wartime research that it was possible to cover only those new products that contributed the most to winning the war, or that have the greatest peacetime potentialities.

Space does not permit a full account of the important role played by the laboratory and its staff of 700 persons during the war. Suffice it to say, however, that improvements in packaging overseas shipments saved over one billion board feet of critically scarce lumber per year. In several instances, careful redesign of packaging in cooperation with the Army Ordnance Department, the Army Air Forces and the War Food Administration reduced damage loss to overseas shipment from 50 percent to 3 percent.

Improved resins and new methods used in the rapid curing of glued laminated timbers by high-frequency electrostatic heating was an invaluable contribution to shipbuilding. Advancements in the fire-retardent treatment of vast quantities of timber used in war plants construction undoubtedly decreased the loss of production from fire hazards.

Accelerated research conducted at the laboratory in cooperation with the Army and Navy air forces, the Navy Bureau of Aeronautics and the Civil Aeronautics Administration was vitally important to aircraft production. Among the several new products developed in this field were improved plywoods, paper-base laminates, wood plastics, "sandwich" construction and a host of modified woods.

New postwar products

One of the Forest Products Laboratory's most promising wartime developments in plastics is a paper-base laminate termed "papreg." It is produced by impregnating sheets of special paper with synthetic resin and compressing them together under heat to form either flat or curved surfaces. Papreg is about one-half as heavy as aluminum, yet has a tensile strength of 35,000 to 50,000 psi. It has been made successfully in sizes up to 8 x 16 ft.

Limited tests indicate that papreg can be used for certain structural aircraft parts such as tail fins, wings and fuselages. Other possible commercial uses include large home radio and refrigerator cabinets, industrial and home electric fan blades, and helicopter rotor blades.

The new resin-treated paper used in making papreg also has an extensive commercial use as a plywood overlay. So used, it would reduce the surface checking of some plywoods and would permit the use of lower grade plywood by concealing surface defects in the wood. It is expected to find considerable use as paneling in homes and offices and in furniture.

"Sandwich" construction

Another new product now undergoing extensive research at the laboratory is called "sandwich" construction. Basically, it is a combination of high-strength facing materials glued to a lightweight core. Thin sheets of aluminum, plywood, papreg or glass cloth are used as facing materials. The cores may be balsa, cellulose acetate, pulpboard treated with resin and cured to impart strength and water resistance, or a honeycomb cellular type structure made from resin-impregnated paper.

Certain fabrication and gluing techniques required in sandwich construction remain to be perfected. But it is expected to play an important role in the commercial manufacture of soundproof partitions for boats, aircraft and railroad passenger cars, as well as of doors, prefabricated house panels and in a number of aircraft assemblies where both light weight and maximum rigidity are required.

New modified woods

Four new modified woods, developed by the laboratory and produced almost exclusively for military purposes during the war, show widespread possibilities for commercial production. They have been termed "impreg," "compreg," "staypak" and "stabwood."

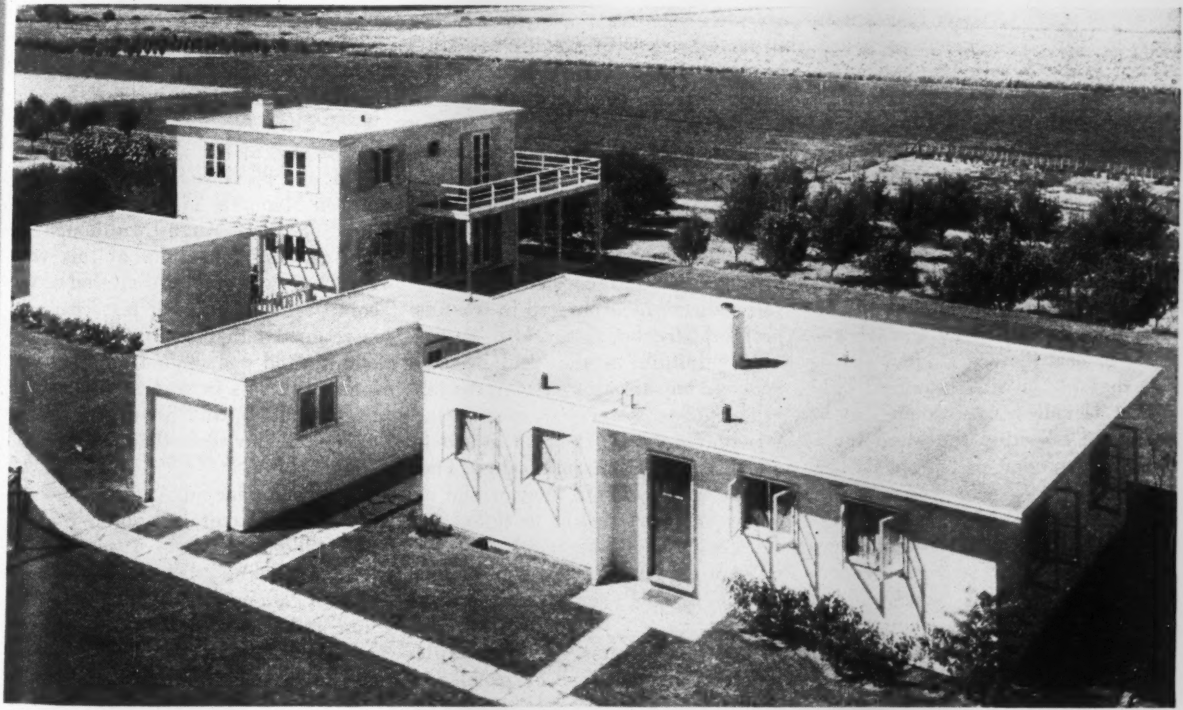
Impreg is any of several species of wood which has been treated with resin-forming chemicals according to a special process developed by the laboratory, followed by curing of the resin without compressing the wood.

One basic requirement in producing impreg is that the impregnating resin must be uniformly distributed throughout the entire cell-wall structure of the wood. Consequently the process is not yet economically adaptable to treating lumber in commercial lengths. However, the process may be applied to almost any species of wood veneer and to solid timbers up to 2 ft. long. Impreg is unusually resistant to decay, termites and marine borers. It also has a high resistance to electricity and is not affected greatly by chemicals other than alkalies.

Impreg shows the greatest promise commercially as resin-treated facing for ordinary plywood. Such panels could be used advantageously as house, trailer and box car siding material, and for flooring and paneling, providing the improved properties warrant the increased cost of treatment. It also may find use for housing electrical control equipment.

Characteristics of "Compreg"

Compreg is the name given by the Forest Products Laboratory to their stable form of resin-treated compressed wood. Its dimensional stability, resistance to organisms, chemicals and flow of electricity are practically the same as for impreg. Compreg, made of any of several ordinary woods and compressed under heat and considerable pressure to a specific gravity of about 0.9 to 1.4 as-



Prefabricated houses developed by the laboratory before the war contributed measurably to emergency wartime housing. Floors, walls and roof in these houses are all built according to the "stressed-covering" principle, plywood panels being glued to the framework to carry part of the load.

sumes a glossy finish which persists throughout the structure. Cut surfaces can be sanded and buffed to a high degree of finish without the use of applied coatings. This feature alone, makes it desirable for use in furniture and flooring.

Wide use for "Compreg"

During the war, aircraft propellers were carved from thick compreg blanks, using metal-working tools. Solid compreg shows promise for commercial use in pulley and gear wheels, bearings, tooling jigs, high-strength electrical insulators, knife handles and a host of decorative novelties. Compreg may replace fabric-reinforced plastics in some cases, as its cost of production should be relatively less.

Unfortunately, both impreg and compreg are more brittle than the original wood. To meet the demand for a compressed product tougher than compreg, the laboratory developed a material named "staypak," which is a compressed wood containing no resin. It is made by modifying the compressing conditions so as to cause the lignin-cementing material between the cellulose fibers to flow sufficiently to eliminate the internal stresses.

Staypak is not so water resistant as compreg, but it is twice as tough and has higher tensile and structural properties. Under weathering conditions, staypak is definitely inferior to compreg, but it can be used in the same manner where extremely high resistance to water it not needed.

Imparting dimensional stability

The cheapest and simplest method of imparting dimensional stability to wood thus far found by the laboratory is to heat the wood under conditions that just avoid charring. This product is called "stabwood." It is produced by heating the wood for a few minutes under molten metal. The wood, so treated, becomes dark brown in color, loses about one-half its original toughness, together with moderate losses in other strength properties.

Stabwood is quite resistant to decay and its equilibrium swelling and shrinking is reduced to about 60 percent of that for the untreated wood. Commercially, it can be used where dimensional stability and resistance to decay are more important than the need for high structural strength.

Research in the field of high-speed curing of glued laminated timbers conducted by the laboratory during the past four years not only was a major contribution to the war effort but also should benefit commercial production as well.

Two methods are used, both employing high-frequency electrical energy. In one, the electric current is transmitted directly through the glue surfaces, setting them in a matter of seconds with very little heating of the wood. The other method uses a specially designed "gun" which concentrates the high-frequency energy over a very small area. This spot-gluing was invaluable in aircraft assembly and it can be used advantageously to tack veneers together in plywood molding operations, thus avoiding the necessity for using metal staples.

Building research

Building research by the Forest Products Laboratory, interrupted by the war, is now being resumed. Considerable study has been given to the factory fabricated house, with plywood the main material and utilizing the "stressed covering" principle which was applied so successfully in aircraft construction to secure strength and light weight. By this method, plywood sheets forming the panel faces are glued to both sides of a structural frame, thus forming a definite part of the load-carrying system.

Two such experimental dwelling houses were developed and erected at the laboratory in 1937. Some of their design and construction innovations were incorporated in wartime prefabricated housing.

In addition to the prefabricated plywood construction system, the laboratory has developed special factory-made panels, 16 x 32 in., to be attached to conventional frames. They can be used for both interior and exterior wall surfaces, or as floors and ceilings. The 32-in. width of panel was adopted to span two stud or joist spaces of the conventional 16-in. spacing.

Extensive commercial possibilities are seen for this type of panel construction, chiefly because the 16x32-in. panels can utilize short lengths of nominal 1-in. low-grade lumber, which ordinarily has a low market value. This method of construction, however, is still in the development stage and no complete houses have been built by it to date.

The Forest Products Laboratory was founded at Madison, Wis. in 1910. Its buildings, including the large main laboratory, which was completed in 1932, are located on land donated by the University of Wisconsin. The laboratory functions under the Forest Service of the U. S. Department of Agriculture and in cooperation with the university.

The organization is headed by Carlile P. Winslow, director, and two assistant directors, George M. Hunt (acting director in the absence of Mr. Winslow who is now in Europe) and L. J. Markwardt.

Groundwater Levels Rising in Memphis Area

Water levels in the 500-ft. wells in the city of Memphis, Tenn., were 0.5 to 1.5 ft. higher in August, 1945, than in the corresponding month of 1944, and outside the city limits they were as much as 3.5 ft. higher, thus reversing the trend, which in recent years has been persistently downward. This information, released by W. E. Wrather, director of the Geological Survey, is based on records obtained by the Geological Survey in cooperation with the Memphis Light, Gas and Water Division.

The rise of the water levels is the result of a decrease in water consumption in Memphis and its vicinity during July and August, although as late as May and June of this year water use was greater than that of the comparable months of last year. It is estimated that pumpage from the 500-ft. sand was about 13 million gallons a day less in August, 1945, than in July, 1945, and about 17 million gallons a day less than in August, 1944.

The pumpage in August from the 500-ft. sand averaged about 84 million gallons a day in 1941, 93 million gallons a day in 1942, 114 million gallons a day in 1943, 110 million gallons a day in 1944, and 93 million gallons a day in 1945.

The decrease in pumpage has resulted from the termination of war production by several of the largest industrial water users in the area and by a number of the smaller users.

From Field and Office

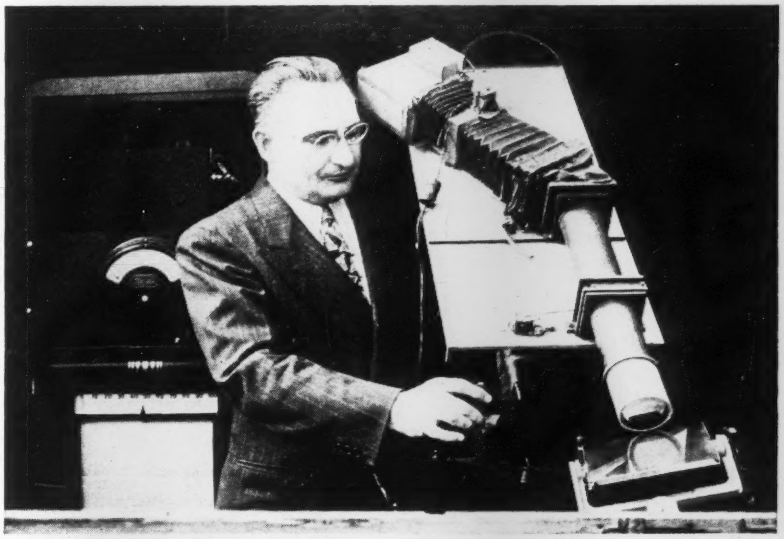
WORKING PROBLEMS AND TIME-SAVING METHODS FOR ENGINEERS AND CONTRACTORS

New Instrument Determines Total Vapor in Atmosphere

An instrument for measuring the total amount of water vapor in a vertical column of the atmosphere has been built by U. S. Weather Bureau engineers. Known as a spectroscopic hygrometer, this tool is expected to prove of considerable importance. A knowledge of atmospheric moisture trends derived from observations taken at frequent intervals, under potential thunderstorm conditions, may assist in bringing about improved forecasting of local thunderstorms. Also, a study of the correlation between the moisture available for precipitation and the amount precipitated under various atmospheric conditions may prove a key to quantitative forecasting, which would be helpful to engineers engaged on irrigation work, water supply engineers, hydro-electric power producers, and the construction industry in general.

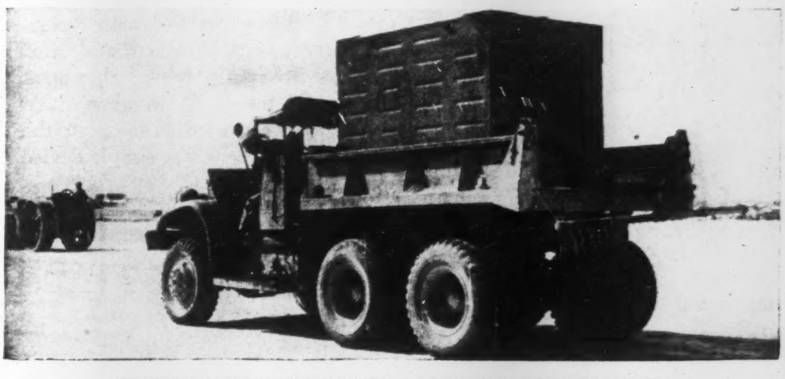
The instrument operates on the well known principle that certain wave lengths of radiation in the infrared region of the sun's spectrum are partially absorbed by the water vapor present in the earth's atmosphere. The percent of absorption is a measure of the amount of water vapor present, and is recorded in terms of the potential depth of the rain if the vapor were all precipitated out. This quantity is termed the "total precipitable water" in the atmosphere.

Radiation from the sun is broken up into its component wave lengths by means of a replica grating. Two narrow slits are located in the resulting spectrum, one in an appropriate absorption band and the other in a nearby portion of the spectrum where no absorption occurs. The ratio of the energy received at the two slits is a function of the absorption caused by the water vapor in the optical path. This ratio varies as the water vapor changes; if only the light intensity changes the ratio remains the same, since the energy at both slits varies in the same proportion.



To measure the total water vapor in a vertical column of the earth's atmosphere the Weather Bureau built the spectrophotometer illustrated. The mirror at the right reflects the sun's rays through a replica grating to energize a phototube, the amplified current being recorded on the sheet at the left. Wm. R. Thickstun, chief of the Weather Bureau's instrument division is shown adjusting the unit.

A phototube located back of the slits acts as the energy receiver, and the energy from the tube is electronicly amplified and fed into a recorder. An aluminum-surfaced, single-mirror heliostat automatically directs the sun's energy into the instrument regardless of the time of day. Readings can be made periodically or continuously as desired, but at present development, readings may be taken only when the sun's disk is unobstructed or when visible through light cirrus clouds. — N. B. Foster, *physicist, U. S. Weather Bureau, Washington, D. C.*



PONTOON USED TO WATER CORAL ON AIRBASE WORK

When paving an airbase on Saipan, Aviation Engineers utilized a Navy pontoon as illustrated for watering the coral in front of the finishing roller. The field was being built to accommodate B-29 aircraft.

Field and Office Comment

Use of Secants and Cosecants In Azimuth Calculations

Sir: Instead of haversines, as proposed by William H. Brady (*ENR* Mar. 22, 1945, vol. p. 409), the writer prefers to compute true azimuths by the use of secants and cosecants. These functions are always greater than unity, hence negative logarithms are avoided.

The method is further simplified by use of a table of log secants and log cosecants recently compiled and published by me, complete to every 0.2 min. of arc. Similar sets of tables to the nearest 0.5 min. have long been in use by navigators to the extent that the haversine method, originally introduced by navigators, is rapidly becoming obsolete.

Using only secants and cosecants, the azimuth formula is:

$$\csc^2 \tfrac{1}{2} Z = \frac{\csc x \csc y}{\sec \phi \sec h} \qquad (1)$$

in which

$x = (45° - \tfrac{1}{2}\delta) + \tfrac{1}{2}(\phi - h)$

$y = (45° - \tfrac{1}{2}\delta) - \tfrac{1}{2}(\phi - h).$

The symbols Z, δ, ϕ, and h, conforming to the notation used by Brady, denote azimuth, declination, latitude and altitude respectively.

Eq. (1) was derived from

$$\sin^2 \tfrac{1}{2} A = \frac{\sin \frac{1}{2}(a+b-c) \sin \frac{1}{2}(a-b+c)}{\sin b \sin c} \qquad (2)$$

which applies to a spherical triangle whose angles are A, B and C with opposite sides a, b and c. Letting $A = Z$, $a = 90° - \delta$, $b = 90° - h$, and $c = 90° - \phi$, Eq. (2) leads to Eq. (1).

Use of Eq. (1) is best illustrated by solution of the same problem as that given by Mr. Brady. Log cosecants and log secants will be designated by the letters A and B respectively. Since the numerator of Eq. (1) is a product of two cosecants it will be represented by the sum of two A's while the denominator, being the product of two secants, will be represented by the sum of two B's. Arrangement of the accompanying work sheet is self explanatory.

$\delta = 12° 05.6'$ N

$\phi = 37° 58.3'$ N

$h = 31° 25.0'$

$2\,|\,6° 33.3'$

$\tfrac{1}{2}(\phi - h) = 3° 16.6' =$ item (a)

$45° 00'$

$\tfrac{1}{2}\delta = 6° 02.8'$

$38° 57.2' =$ item (b)

$3° 16.6' =$ item (a), repeated

$x = 42° 13.8' =$ item (b) + item (a)

$y = 35° 40.6' =$ item (b) − item (a)

Sum $= 77° 54.4' = 90° - \delta$ (check)

ADD SUBTRACT ADD

Take Half

$x = 42° 13.8'$ A 17256

$y = 35° 40.6'$ A 23417

$40673 \longrightarrow 40673$

$\phi = 37° 58.3'$ B 10330

$h = 31° 25.0'$ B 6885

$17215 \longleftarrow 17215$

$2\,|\,23458$

$\tfrac{1}{2}Z = 49° 45.5' \longleftarrow A\ 11729$

$Z =$ N99° 31.0′E

With a work form similar to that shown, one may proceed without being conscious of using logarithms. It will be noted that the sum of x and y must equal $90° - \delta$, hence an error in the preliminary calculations can be caught before referring to the tables. The compass bearing will catch any gross error in the azimuth computations.

The values of x and y are interchangeable in the formula hence when h is greater than ϕ, use $h - \phi$. When declinations are south, the values of δ are negative provided the north pole is the elevated pole, as it would be for northern latitudes.

In case the time t is desired when the declination, latitude and altitude are known, a similar expression to that of the azimuth formula is:

$$\csc^2 \tfrac{1}{2} t = \frac{\csc x' \csc y'}{\sec \phi \sec \delta} \qquad (3)$$

in which

$x' = (45° - \tfrac{1}{2}h) + \tfrac{1}{2}(\phi - \delta)$

$y' = (45° - \tfrac{1}{2}h) - \tfrac{1}{2}(\phi - \delta).$

It will be noted that Eq. (3) is the same as Eq. (1) except that the letters δ and h, representing declination and altitude, are interchanged. Also, it follows that the quantity x' is the same as x.

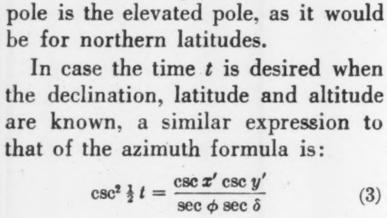
For an exact check on the computation of Z and t, the law of cosecants (law of sines) may be used. Thus:

$$\frac{\csc Z}{\sec \delta} = \frac{\csc t}{\sec h}. \qquad (4)$$

—Thomas F. Hickerson, *Professor of Applied Mathematics, Univ. of North Carolina, Chapel Hill, N. C.*

Simple Device for Anchoring Tainter Gate Sills

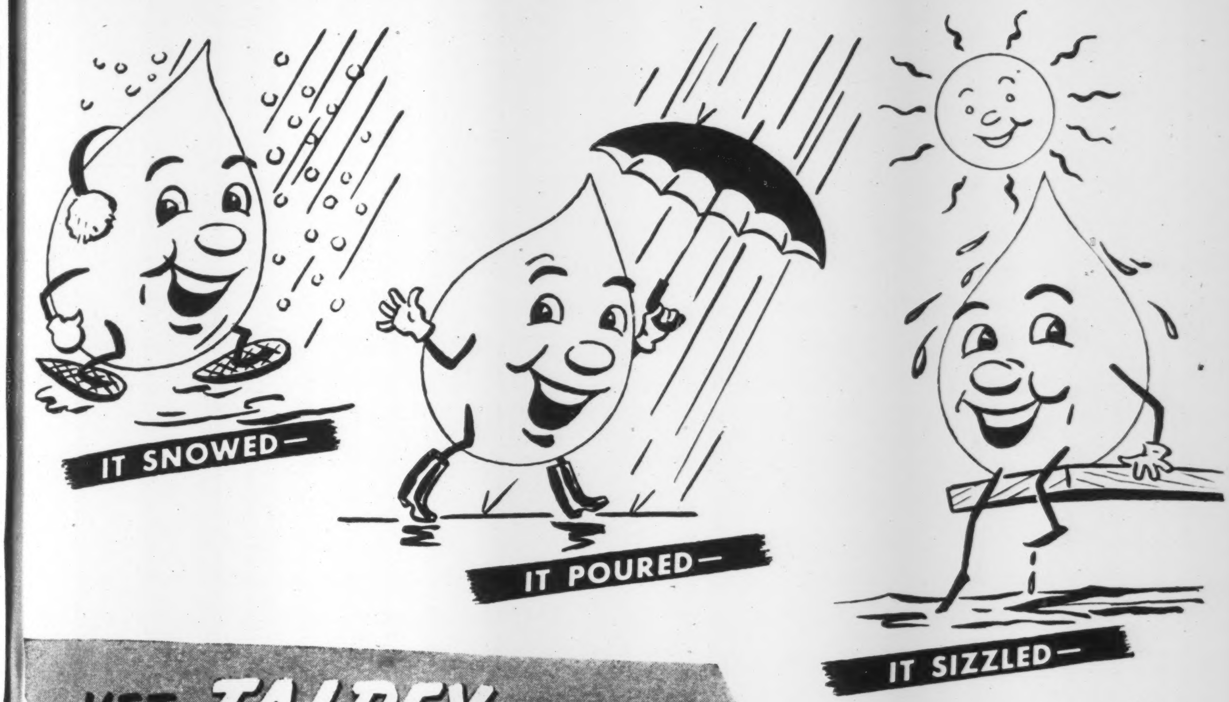
In placing the sill and side rubbing plates for tainter gates, it is customary to leave a slot or recess in the concrete, with anchors to which the sill or plates may be attached, and, after being brought into alignment, grouted in place. A number of devices have been used to facilitate this work of alignment. A simple device, easily made and installed, is illustrated in the accompanying drawing.



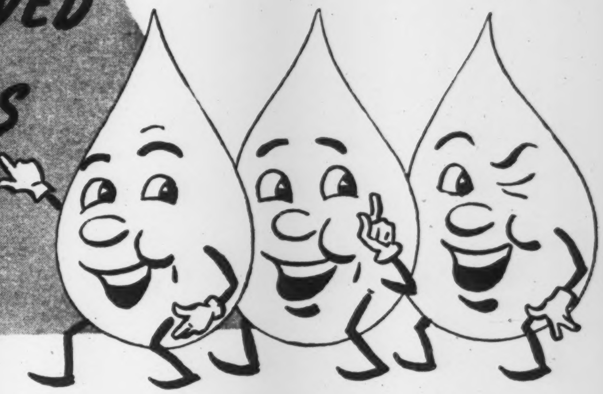
Similar anchors may be attached to clip angles welded to plates for sills or side plates.

Here the anchor is attached to a tee, but it can be attached to clip angles welded to a plate. The slotted holes are easily cut with a torch. The use of small jacks, such as planer jacks used by machinists, will aid in bringing the tee or plate into alignment for bolting.

The anchors should be set slightly outside the theoretical position, so that the tee or plate may be shimmed into correct alignment. The illustration shows the anchors bent, but they may be made straight if desired. No dimensions are given, but the anchors should be heavy enough to resist bending if pressure is required to bring the tee or plate into alignment.—G. G. Commons, *Office Engineer, State Board of Water Engineers, Austin, Tex.*


IT SNOWED—
IT POURED—
IT SIZZLED—

—YET TALPEX PROVED IDEAL FOR DIESELS IN 56,979-HOUR FIELD TEST!



CAREFULLY supervised field tests of Shell Talpex E in 37 Caterpillar engines during 56,979 hours of operation proved it the ideal Diesel engine oil—regardless of weather.

In the field tests a sample of each drain was kept for analysis. In each, Talpex E showed inherent oxidation stability and resistance to deterioration.

Four of the engines were dismantled for examination after some 1000 hours of operation. All four were exceptionally clean throughout and showed complete freedom from ring-sticking and bearing corrosion.

In the final analysis, Talpex E proved to be the ideal lubricant for high-speed Diesel engines. Beside lubricating, hard-working Talpex E provides *extra* qualities: (1) High detergency; (2) Exceptional oxidation stability; (3) Low carbon-forming tendency; (4) Is non-corrosive to alloy bearings.

✓ ✓ ✓

For further information on Shell Diesel lubricants get in touch with Shell Oil Company, Incorporated, 50 West 50th Street, New York 20, New York; or 100 Bush Street, San Francisco 6, California.

SHELL DIESEL LUBRICANTS

SHELL

CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

Wall and Appurtenant Works Portsmouth-New Boston, Ohio River

OWNER: United States Engineers, Court House Building, Cincinnati, Ohio, Col. Peschal N. Strong, chief engineer.

PROJECT: The flood wall and appurtenant works to be constructed are a part of a project for protecting the low lying portions of the cities of Portsmouth and New Boston, Ohio, from being flooded during the occurrence of high water in the Ohio River. The major structures are to be a reinforced concrete wall (approximately 7300 feet long and 20 feet high), gate abutments, gate and gate storage house, access bridge, sluice gate well, trash rack, sewer and perforated drains. The site of the work is in the cities of Portsmouth and New Boston, Scioto County, Ohio. These two cities are located on the right bank of the Ohio river, about 356 miles below Pittsburg, Pennsylvania.

CONDITIONS: Contractor to furnish all materials, equipment supplies, labor and transportation, including fuel, power and water. The contractor will also preserve and protect all existing vegetation such as trees, shrubs and grass on or adjacent to the site which do not reasonably interfere with construction. Rail, highway and water transportation (Ohio River) is available. Power may be secured from the Ohio Power Company and water from the municipally owned utility in the city of Portsmouth. The contractor is to provide the water supply to the site, laying all necessary piping and at the termination of the work this piping must be removed. One condition that may arise is the flooding of the Ohio river and if this should occur and damage results to the work through no fault of the contractor additional payment will be made at the unit or lump sum prices established in the contract. The prevailing wage rates are to be: $1.625 per hr. for skilled labor; $1.00 to $1.50 per hr. for semi-skilled and $.75 per hr. for common. The bids were received on August 21, 1945 and the stipulated contract time is August 31, 1946, allowing about 365 calendar days for the work.

BIDS: Five bids were received on August 21, 1945, ranging from the contract low of $854.892.00 to the high of $1,038,618.00

LIST OF BIDDERS:

1. Dravo Corporation, Pittsburg, Pa. (contract)	$854.892.00
2. Foster & Creighton Co., Nashville, Tenn.	904.197.00
3. Johnson, Drake & Piper, Inc., New York, N. Y.	936.306.00
4. L. B. Strandberg & Son, Chicago, Ill.	941.585.00
5. LaCrosse Dredging Corp., Chicago, Ill.	1,038,618.00

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing, grubbing and removal of structures	1 job	$1,500.00	$4,000.00	$7,000.00
2. Removal of concrete walls and foundation	317 cu. yd.	10.00	5.00	13.00
3. Removal of portion of 96" x 96" reinforced concrete sewer	28 lin. ft.	300.00	200.00	100.00
4. Structure excavation including stripping for embankment	64,000 cu. yd.	1.25	1.90	1.55
5. Compacted backfill	71,000 cu. yd.	.95	1.10	1.90
6. Uncompacted backfill	145,000 cu. yd.	.70	.65	.65
7. Sand and coarse aggregate filters	4,000 cu. yd.	2.70	1.70	3.50
8. Concrete	20,000 cu. yd.	18.00	19.00	17.65
9. Reinforcement steel	2,703,000 pound	.06	.06	.065
10. Dumped riprap	3,550 cu. yd.	12.00	7.00	6.00
11. Perforated reinforced concrete pipe 10" diameter	7,300 lin. ft.	3.00	2.00	1.50
12. Reinforced concrete pipe 12" diameter, complete	76 lin. ft.	3.00	12.00	1.20
13. Access bridge, complete	1 job	2,100.00	1,100.00	3,850.00
14. Manholes (brick) complete, except excavation and backfill	2 each	300.00	140.00	200.00
15. Miscellaneous metal	7,850 pound	.30	.40	.36
16. Gate storage house door & frame for gate No. 10	1 each	450.00	310.00	300.00
17. Louvers	3 each	70.00	30.00	50.00
18. Hand rail	213 lin. ft.	6.00	5.00	7.00
19. Sluice gate 7'-0" wide x 7'-0" high	1 each	4,500.00	5,300.00	5,000.00
20. Movable gate closure No. 10	1 job	1,400.00	1,400.00	2,500.00
21. Cement	25,000 bbls.	2.25	2.70	2.80
22. Copper water stop	15,000 pound	.75	.60	.50
23. Compacting for three additional passes	1,000 100 s. f.	.05	.35	.25
24. Top soil	1,900 cu. yd.	1.00	.70	1.60
25. Seeding	2.4 acre	100.00	200.00	300.00
26. Sewer pipe, 10" diameter plain, complete	150 lin. ft.	1.50	1.55	.80
27. Sewer pipe 6" diameter, plain and perforated, complete	60 lin. ft.	1.50	.70	1.00
28. Catch basins, complete except excavations and backfill	2 each	150.00	90.00	100.00
29. Grouted gutters	28 cu. yd.	30.00	27.00	30.00
30. Drilled week holes 3" diameter	26 lin. ft.	1.00	10.00	3.00
31. Gate storage house door and frame for Gate No. 9	1 each	450.00	230.00	400.00
32. Moveable gate closure No. 9	1 job	2,000.00	1,500.00	3,000.00

Grading, Drainage, Surfacing Whatcom Co., Wash.

OWNER: State Highway Department, Olympia, Wash.; Clarence Hickey, State Highway Director in charge.

PROJECT: Grading, drainage, surfacing plus removal of two bridges and 960 sq. yds. of existing concrete pavement. Work is on the Secondary State Highway, 1A, in Whatcom Co., Wash. and will include the laying 364 feet of concrete drainage pipe.

CONDITIONS: Contractor to furnish all materials and complete work in 90 calendar days. Highway transportation facilities available only. Wage rates stipulated as minimums are $1.60 to $1.70 per hour for skilled labor; $1.15 to $1.40 for semi-skilled; and the reasonably high figure of $1.15 per hour for common labor.

BIDS: Nine bids were received on April 3, 1945. The nine bids ranged from the contract low of $30.731 to $40.919.

LIST OF BIDDERS:

1. G. J. Norris, Seattle, Wash. (Contract)	$30.731
2. P. J. Anderson & Sons, Seattle Wash.	30.953
3. Dawson Constr. Co., Bellingham, Wash.	31.700
4. C. V. Wilder Co., Bellingham, Wash.	33.290
5. Harrison Bros. Co., Tacoma, Wash.	33.507
6. A. Lind, Bellingham, Wash.	33.909
7. Romano Engineering Co., Seattle, Wash.	37.424
8. Beal & Roberts, Seattle, Wash.	37.727
9. A. W. Stevens Constr. Co., Mount Vernon Wash.	40.919

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing and grubbing	Lump Sum	$1,000.00	$1,200.00	$1,000.00
2. Unclassified excav., incl. haul.	25,560 c. y.	.75	.70	.70
3. Trench excavation, incl. haul.	80 c. y.	1.00	1.00	2.00
4. Structural excavation	230 c. y.	1.50	2.00	2.00
5. Slope treatment	2,675 ft.	.12	.20	.15
6. Finish roadway	23 stations 100 ft.	12.00	15.00	20.00
7. Sel. rdwy. borrow in pl., incl. haul	2,500 c. y.	1.00	.95	1.25
8. Sand filler in place, incl. haul.	110 c. y.	.75	3.00	2.00
9. Gravel backfill in place	110 c. y.	2.50	3.00	3.00
10. One course scr. grvl. surfg. in place	600 c. y.	2.00	3.00	2.50
11. Stand. guard rail, type 5, in place	915 ft.	.80	1.75	1.80
12. Stand. open wd. flume in place	110 ft.	1.00	1.50	1.00
13. Remove existing concrete pavement	960 s. y.	.25	.75	1.00
14. Remove 2 existing tbr. bridges	Lump sum	$2,000.00	$1,000.00	$1,100.00
15. 12-in. concr. or V. C. culv. pipe, in place	108 ft.	1.50	1.00	1.75
16. Stand. reinf. concr. culv. pipe, 24-in., in place	12 ft.	3.50	5.00	4.00
17. 36-in. extra str. reinf. concrete culvert pipe in place	244 ft.	9.00	8.00	8.60

New Aids to the Constructor

MANUFACTURERS' LATEST DEVELOPMENTS IN EQUIPMENT AND MATERIALS

Hydraulic Bore

Self-contained and driven by a separate gasoline motor, a new hydraulic earth boring machine is mounted on a sturdy steel underframe. No manual labor is needed in plumbing this unit, which will bore anchor holes up to 45 deg. angle.

The controls are within easy reach of the operator. Hydraulic pressure controls the plumbing and vertical motion of the bit, and the hydraulic feed automatically regulates drilling speed to suit soil texture. The machine carries any size bit up to 24 in. dia. and can bore 8 or 9 ft. deep.—*Jaques Power Saw Co., Denison, Texas.*

• • •

Photo-Print Dryer

Even heat is maintained in the new B-8 photo-dryer by additional electrical heating elements. Thermostatic control is available and variable speed drive motors and controllers permit speed changes from 6 in. to 3½ ft. a minute.

Available in 26 and 44-in. widths, the dryer has a chromium-plated copper drum, a seamless band and pressed-steel framework.—*Peck & Harvey, 4327 Addison St., Chicago 41, Ill.*

• • •

Traffic Control

Designed to handle troublesome left-turn intersections, a new Reco 7-circuit traffic control is equipped with silver contacts and has a synchronous 115-volt, 60 cycle A-C motor. It may also be fitted for whatever number of circuits is required, and for other current specifications and time cycles.

The flashing action of the control is said to be sharp and clean, the amber and green lights going off together. It is strongly built for long service.—*Reynolds Electric Co., 2650 West Congress St., Chicago 12, Ill.*

• • •

Self-Healing Flooring

Intended for application directly over old concrete a new colloidal flooring material, Stonoleum, is resilient and resistant to vibration and heavy loads. As this product bonds directly, pitted and cracked floors do not have to be chipped away, nor is any adhesive necessary.

This flooring, with many of the characteristics of concrete, does not dust, crack, pit or crumble, it is claimed. It is also said to be self-healing, holes coalescing quickly under traffic.—*Continental Asbestos & Refining Corp., 1 Madison Ave., New York 10, N. Y.*

• • •

Welding Positioner

Rotating work up to 700 lb. at speeds from 0 to 2.4 rpm., a new powered welding positioner will accommodate table speeds up to 180 in. per minute, with a work radius of 1 ft.

The 28-in. dia table may be adjusted from 30 to 36 in. from the floor, and tilts through 135 deg. from the horizontal by means of a hydraulic cylinder and gear segments.

The positioner is provided with a built-in "Standard" variable speed transmission and hydraulic cylinder, with a single ½ hp. 110, 220 or 550-volt electric motor. It is 39½ in. long overall, and weighs 665 lb.—*Standard Machinery Co., Providence, R. I.*

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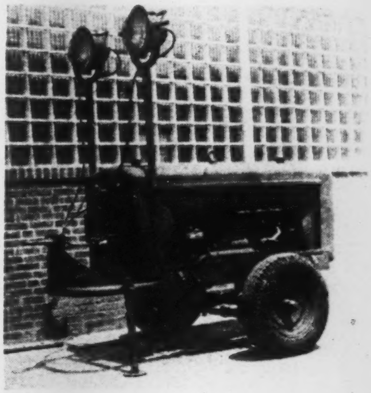
Compressor-Generator



A new compressor-generator outfit has an actual air delivery of 60 cu. ft., according to the manufacturer's statement, and is equipped with a 5 kw. generator with an adjustable floodlight.

The outfit, completely automatic, with a push button electric starter, is mounted on a two-wheel spring trailer. —*Schramm, Inc., West Chester, Pa.*

• • •

Safety Spectacles

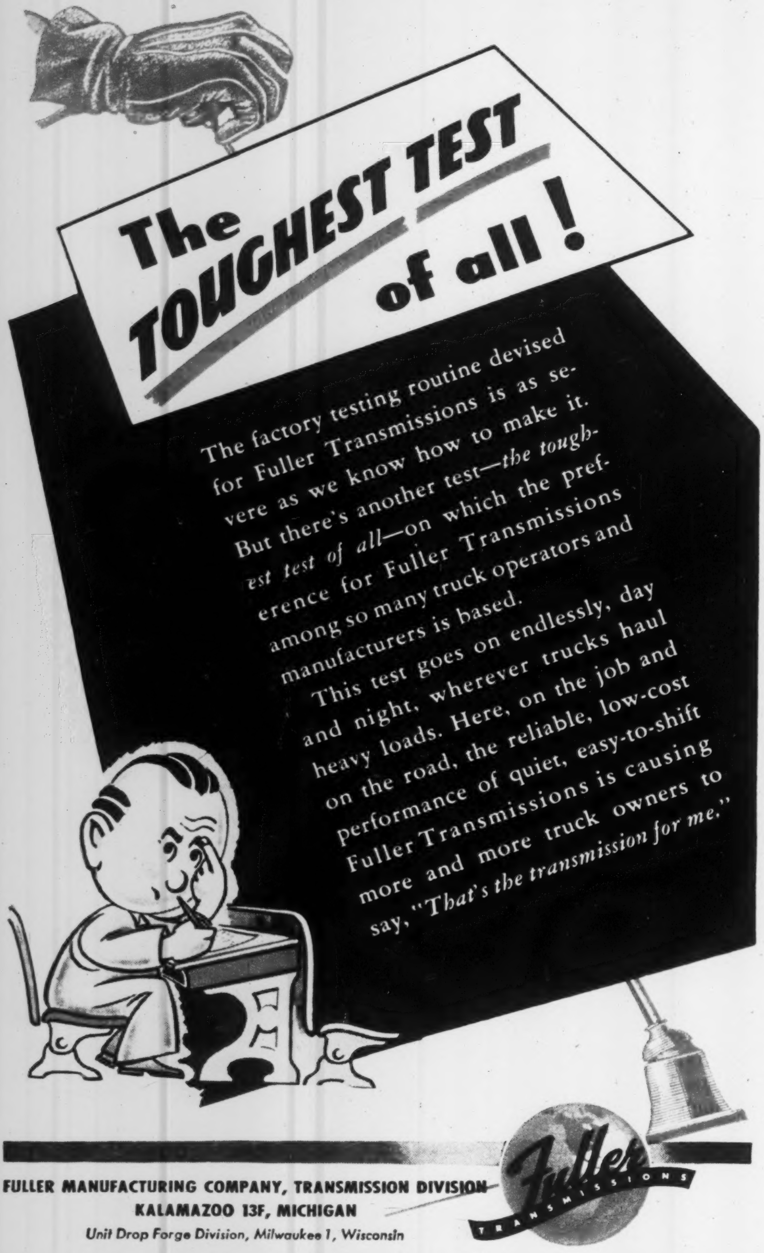
Like smart eyeglasses in appearance, new safety spectacles in 20 frame sizes fit any type of face. Special comfort features are: custom fit; plastic rocker nose pads, which are self-adjusting to the size of the bridge; and adjustable cable temples. Maximum eye protection is afforded by heat-treated Super-Tough lenses; every lens is individually tested for impact strength, and the frames are reinforced.

The spectacles, in clear or Willsonite green glass, are provided with or without any one of ten types of side shields, and with flat or curved lenses.—*Willson Products, Inc., Reading, Pa.*

• • •

Glass Mat

A thin, porous mat of bonded glass fibers has been developed, in roll form, for wrapping underground oil, gas and other pipelines to protect them against corrosion and electrolytic action. If wrapped around bitumen or coal-tar coated pipe, this mat is said to form a



The TOUGHEST TEST of all!

The factory testing routine devised for Fuller Transmissions is as severe as we know how to make it. But there's another test—*the toughest test of all*—on which the preference for Fuller Transmissions among so many truck operators and manufacturers is based.

This test goes on endlessly, day and night, wherever trucks haul heavy loads. Here, on the job and on the road, the reliable, low-cost performance of quiet, easy-to-shift Fuller Transmissions is causing more and more truck owners to say, "*That's the transmission for me.*"

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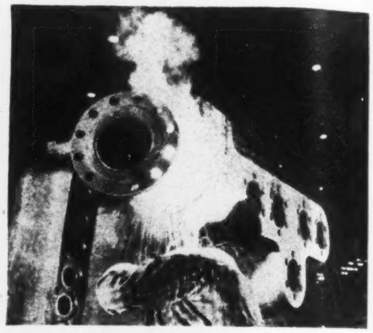
continuous water-tight bond.

The glass fibers are non-corrosive to metals and the Fiberglas mat picks up very little moisture. It holds its tensile strength under temperature variation, and exposure to organic solvents and soil acids.—*Owens-Corning Fiberglas Corp., Toledo 1, Ohio.*

• • •

Low-Alloy Electrode

Specially designed for use on carbon-molybdenum steel in the high-pressure piping industry, a new heavily covered, Type W-56, arc-welding electrode for low-alloy, high tensile steels, has many other industrial uses. Operating on A-C or D-C, with reverse polarity, it has a broad current range to cover numerous plate thicknesses. The electrode, for which a medium long arc is recommended, can be used in flat, vertical or overhead positions and produces a relatively flat deposit.



Features of the electrode include a stable spray-type arc, deep penetration, high creep-resistance. It is obtainable in $1/8$, 5/32 and 3/16 in. dia.—*General Electric Co., Schenectady, N. Y.*

• • •

Bronze Bearing

Especially adapted for fan and blower service, a new bronze bushed Type "F" Bronzoil bearing is fully self-aligning. The spherical inner housing conforms to a spherical socket in the formed steel outer housing.

A bronze capillary, which carries about one-third of its volume of lubricant, is used as a liner; its shoulder provides a broad, flat bearing surface. The oil reservoir with a close fitting wick surrounds the bushing.—*Dodge Manufacturing Corp., Mishawaka, Ind.*

• • •

Quick-Starting Fluorescent

Now available as a heavyweight model, with a lateral reinforcing ribbed reflector for extra strength, the "Quik-Liter" fluorescent lamp starts instantly, without flicker. Combining a hot and cold cathode principle, this lamp will

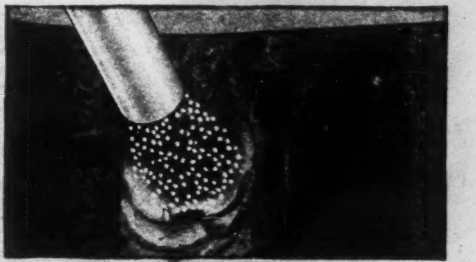
SAYS THE MAN IN THE HELMET—

"I get nice, smooth flat fillets every time with AIRCO No. 78E...

(AWS Classification E 6010)

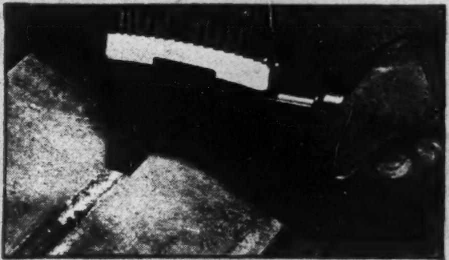
... "It's my favorite electrode for all-position DC reverse polarity welding of mild steel

"Look at that neat, flat fillet. Airco No. 78E gives that type of high quality, flat-faced fillet in all positions, and it's especially good on vertical and overhead.



"Its special coating and its fine spraying action speed up vertical and overhead fillet welds. Metal sets up rapidly and the arc is strong and forceful.

"There's no interference from slag and no deflection in the arc in any position. Deposit speeds are faster than most electrodes. — weld contour is always tops.



"Slag comes off easily, another good feature. That's why I say when the job calls for an AWS E6010 electrode — and when quality, speed and appearance are important — give me Airco 78E every time."

Take a tip from the Man in the Helmet and select your electrodes for their *working ease and efficiency* as well as for their metallurgical properties.

There is a complete line of Airco electrodes for every welding job. Catalog No. 120 gives full details. For a free copy write the nearest Airco office or Dept. EN at the New York address. Air Reduction, General Offices: 60 East 42nd St., New York 17, N. Y. In Texas: Magnolia-Airco Gas Products Co., General Offices: Houston 1, Texas.

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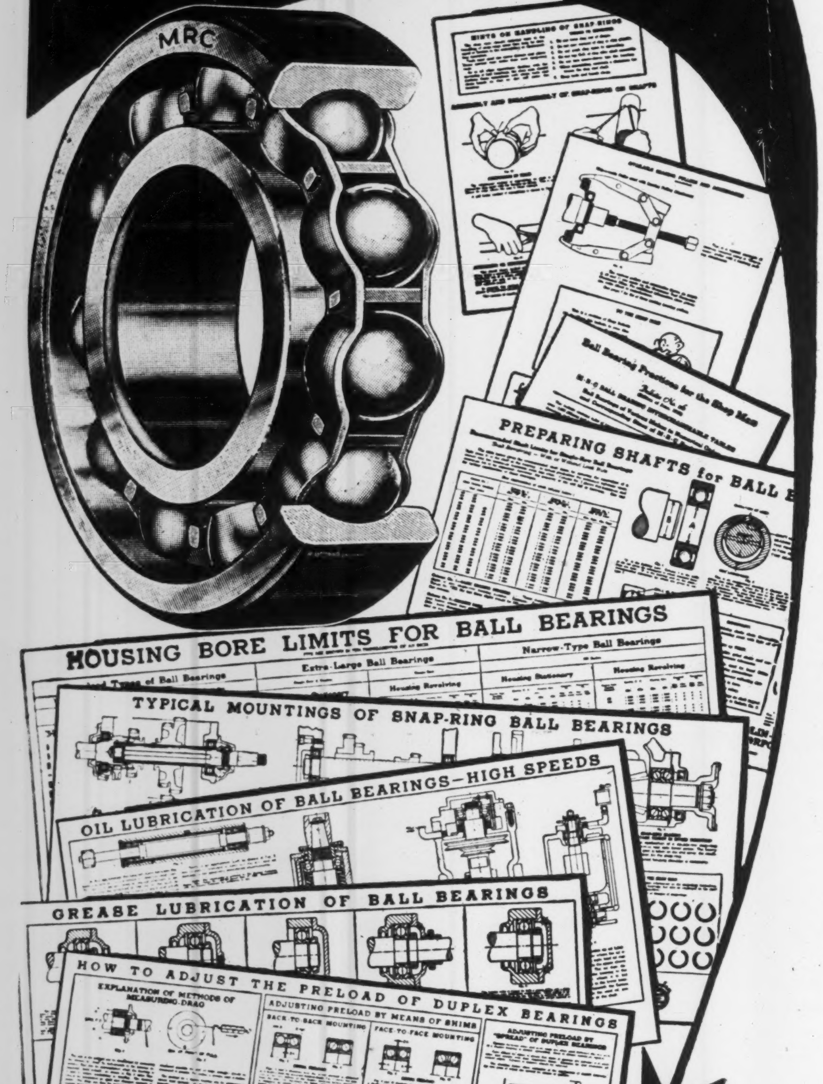
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HOW TO ADJUST THE PRELOAD OF DUPLEX BEARINGS

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M-R-C BALL BEARINGS

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Executive Offices: JAMESTOWN, N. Y.

operate at low and irregular voltages and under extreme temperature conditions. It is available in 2-40 and 4 watt sizes, for 115 or 230 volt, 60 cycle A-C operation.—*The Edwin F. Gu Co., 2615 Washington Ave., St Louis 3, Mo.*

• • •

Pressure Switch

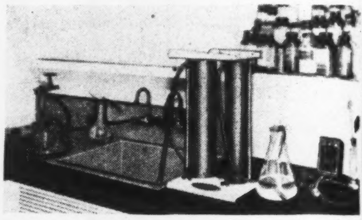
Designed for use with built-in carbon dioxide fire extinguishing systems, the new Kidde pressure switch assists in isolating a fire by automatically cutting off electrical circuits. It is self-contained, of the mercury contact type.

The switch, connected by a bleed pipe from the main distribution line, operates by the carbon dioxide passing through this piping to the discharge nozzles. The device is available for control of two, three or four circuits.—*Walter Kidde & Co., 140 Cedar St., New York 6, N. Y.*

• • •

Portable De-Ionizer

A compact laboratory unit has been developed to inexpensively produce purified water comparable to distilled water, according to the manufacturer's announcement. This "Illco-Way" device, in the portable 12 gal. per hr. model, weighs only 35 lb. and measures 22x13x8 in. A larger 60-gal. unit is also available.



This unit is said to be economical to operate, with no cooling water, heat or fuel required. It does not need periodic dismantling for cleaning, and Saran plastic and hard rubber throughout protect water quality. Water remains under pressure to point of use.—*Illinois Water Treatment Co., Rockford, Ill.*

• • •

Masonry Paint

Some of the outstanding features of Mason-Cote, a new ready-mixed paint for exterior masonry, are: ease of application by brush or spray, even over damp masonry; no saponification caused by masonry alkalinity; excellent adhesion and hiding.

This paint, in white only, does not become brittle, it is claimed.—*The Wilbur & Williams Paint Corp., Boston 16, Mass.*

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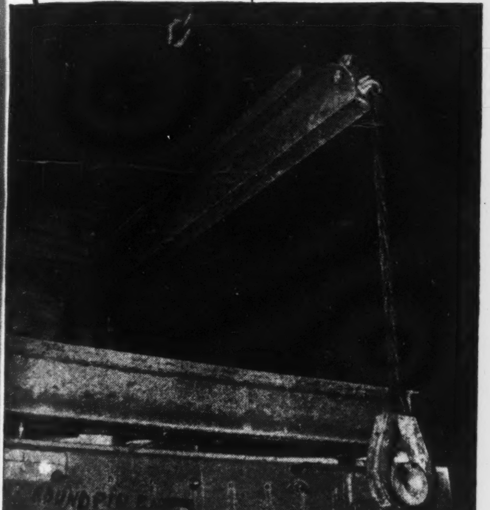

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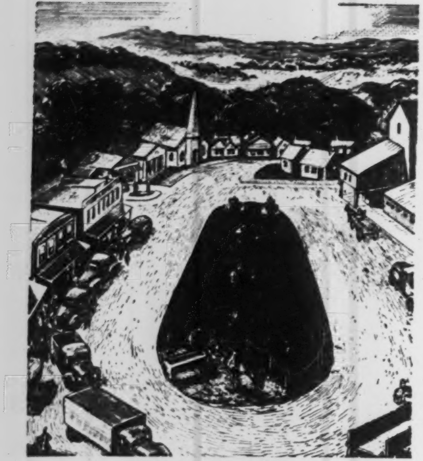

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LAYNE

WELL WATER SYSTEMS
VERTICAL TURBINE PUMPS

Elections and Activities

W. D. Shaw

Donald MacIsaac, president of the Southern California Chapter of the Associated General Contractors of America has announced these changes of personnel: F. J. Connolly who has been manager of the chapter for the last 12 years has resigned for reasons of health. W. D. Shaw has been appointed manager in his place. Mr. Shaw had five years' experience as manager of the Mountain Pacific chapter in Seattle, Wash., during which time he was instrumental in organizing the construction industry in Western Washington and the territory of Alaska. Norris Poulson, former member of the California Legislature and former representative in Congress from Southern California, has been retained as legislative representative.

The labor relations staff of the chapter remains unchanged with J. J. Christian as director, and Frank Boyce as assistant. The labor relations committee has just negotiated a resolution to continue the Southern California master labor agreement, which grants some moderate wage increase, and promises to preserve harmony between labor and employers in the Southern California construction industry.

A new chapter of the Associated General Contractors of America has been formed at Tacoma, Wash. It has absorbed the entire membership and activities of the former Construction Council of Tacoma, representing 88 companies. Both building and heavy construction contractors in Pierce and Thurston counties belong to the new chapter. Officers, all of Tacoma, are Roy T. Earley, president; J. Alden Woodworth, vice-president; Sam Bergeson, secretary-treasurer; L. B. Macdonald and Robert Ketner, directors. William Osborne, who was manager of the Construction Council, is executive secretary and manager of the new organization.

The National Real Estate Foundation, recently incorporated in the District of Columbia, has announced plans to raise a $5,000,000 fund to fight public housing. At its first meeting the foundation elected Arthur Binns, Philadelphia real estate operator, president and N. C. Hines, of Washington, D. C., executive director with offices in Washington. The board of Trustees already numbers over 70, and the plan is to have a board of over 300 persons.

Mayors of 12 communities in the Fox River valley in Illinois met recently and formed the Fox River Valley Mayor's Association to develop recreational facilities and assure an adequate water supply in the section, including Locke, McHenry, Kane, Kendall and LaSalle counties. They elected Walter E. Miller, Elgin, acting president, and R. L. Overton, McHenry, secretary.

The Engineering Foundation has elected Dr. S. B. Kinzel chairman for the coming year. Other officers elected were: Vice-chairman, Dr. L. W. Chubb, director of the research laboratories of Westinghouse Electric Co.; Dr. Edwin H. Colpitts, formerly director of the Bell Telephone Laboratories was reelected director, and John H. R. Arms, reelected secretary. Dr. Kinzel will represent the Engineering Foundation on the executive board of the National Research Council. The foundation was established in 1913 for "the furtherance of research in science and engineering and for the advancement in any other manner of the profession of engineering and for the good of mankind."

The Texas Construction Council was organized in Fort Worth recently. The council is made up of representatives from Texas municipalities, engineers and contractors. The primary purpose is to effect better understanding among engineers, contractors, and city officials, and to develop a standard form contract for use in all municipal construction.

Mayor Joe A. Jenkins, Amarillo, was elected chairman. Representatives from the League of Texas Municipalities are: Mr. Jenkins; R. E. Rouer, Ft. Worth; Homer A. Hunter, Dallas; J. M. Nagle, Houston; and Walter E. Seaholm, Austin. Representatives from Texas Professional Engineers are: T. C. Forrest, Jr., Dallas; H. N. Roberts, Lubbock, and Uel Stephens, Ft. Worth.

Everett R. Read, Elizabeth, Ill., president of the Jo Daviess Soil Conservation district, has been made president of the Northern Illinois Conservation council, which includes the soil conservation districts of 15 northern Illinois counties. Kenneth Ralston, Roscoe, was elected vice-president; H. R. Brunnemeyer, Rockford, succeeded D. E. Warren as secretary.

"50-50"... he hoped for

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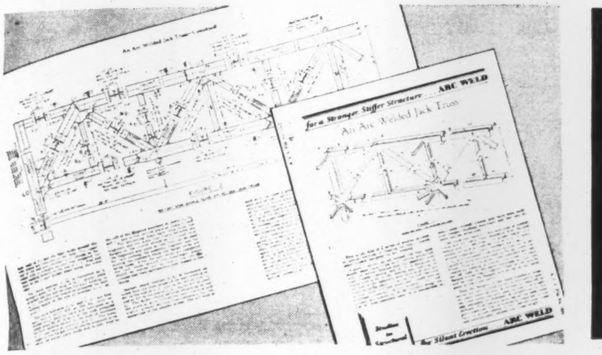
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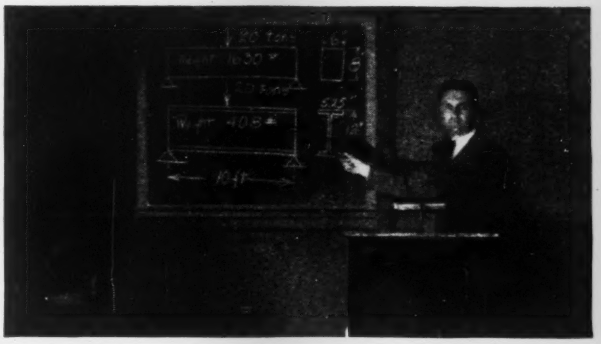
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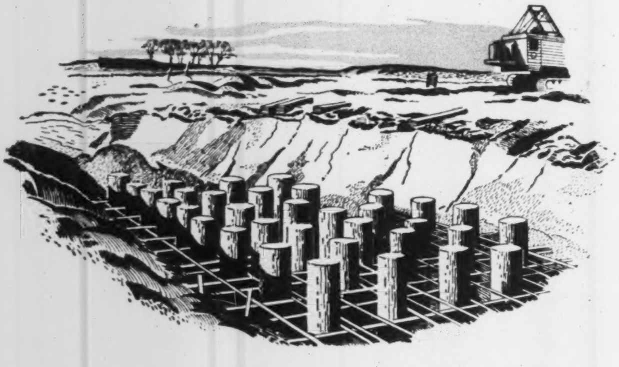

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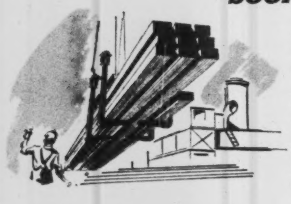

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1649 McCORMICK BUILDING, CHICAGO 4, ILLINOIS

Engineering School News

(*Continued from p. 72*)

James G. Clark, assistant professor of civil engineering, University of Illinois, has returned after having been absent on leave since May, 1944, doing research work in the airplane plant of the Consolidated-Vultee Corp., San Diego, Calif.

Brig. Gen. Max C. Tyler, retiring head of the Mississippi River Commission, has been asked to head a graduate school of hydraulic engineering to be established next semester at Louisiana State University. He has the offer under consideration.

Michigan State College has announced the resignation of Lee J. Rothgary, assistant professor and research assistant in civil engineering. His successor has not been chosen. Dr. Charles H. Cunningham has been appointed associate professor of public health.

M. K. Snyder, head of the department of civil engineering at Washington State College since 1931, has retired and will make his home at Sequim, Wash.

Walter T. Rolfe, coordinator for the University of Texas Veterans Advisory Service, says questionnaires returned by 424 ex-service men reveal 152 intend to study engineering.

The Youngstown, Ohio, College board has changed the name of the new William Rayen Technical Institute to the William Rayen School of Engineering, it has been announced by Dr. Howard W. Jones, college head.

George W. Clark, associate professor of civil engineering at Ohio University, Athens, Ohio, has been selected by the War Department to serve on the faculty of one of the university study centers to be used in the Army education program for troops in the ETO.

The College of Engineering at the University of California, Los Angeles, has received a gift of $15,000 from the Deutsch Engineernig Co., it is announced by Dean L. M. K. Boelter. The funds, to be used on projects carried out by graduate students, is especially welcome because it represents the first contribution to research in the new college, Dean Boelter said.

UNIT 514

So Easy to Handle
UNIT
CRANE

CLAMSHELL
DRAGLINE
TRENCHOE
MAGNET
Convertible
TO ALL ATTACHMENTS

Full-Vision Cab ... ENABLES OPERATOR TO SEE IN ALL DIRECTIONS

Here's a sturdy, nimble ½-yard excavator with compact, streamlined design ... built for safe, efficient operation. Fast, finger-tip responsiveness. All controls within easy reach of operator. Automatic, foolproof traction brakes. New full vision cab, equipped with shatter-proof glass, promotes safety and increases operating efficiency.

Write for Catalog No. 45-A.

½ AND ¾ YD. EXCAVATORS UNIT CRANE & SHOVEL CORP. UNIT MILWAUKEE WISCONSIN **5 TO 10 TON CRANES**

UNIT CRANE & SHOVEL CORP. **MILWAUKEE 14, WISCONSIN, U.S.A.**

A 4873-1P-C

Worthington-Ransome Blue Brute Distributors

By referring to the advertisement on page 131 you'll learn the meaning of the (1), (2) or (1-2) beside their names.

Ala., Birmingham (1) J. D. Pittman Tractor Co.
Ariz., Phoenix (2) Smith Booth Usher Co.
Ark., Fort Smith (2) R. A. Young & Son
  Little Rock (1) Kern-Limerick, Inc.
  Little Rock (2) R. A. Young & Son
Calif., Los Angeles (1) Garlinghouse Bros.
  Los Angeles (2) Smith Booth Usher Co.
  SanFrancisco (1-2) Coast Equipment Co.
Colo., Denver (2) John N. Meade
  Denver (1–2) Power Equipment Co.
Conn., Hartford (2) The Holmes-Talcott Co.
  New Haven (1) W. I. Clark
  Waterbury (1) Contractors Supply Co.
D. C. Washington (1) M. A. Doetsch Machinery Co.
Fla., Miami (1–2) Allied Equip., Inc.
  Orlando (1–2) High Equip. & Supply Co.
Ga., Atlanta (1–2) Tractor & Machinery Co.
  Savannah (1) Morgans, Inc.
Ida., Boise (1–2) Olson Manufacturing Co.
Ill., Chicago (1–2) Chicago Construction Equipment Co.
  Chicago (1–2) John A. Roche
  Chicago (1) Thomas Hoist Co.
Ind., Fort Wayne (1) American Steel Supply Co.
  Indianapolis (2) Reid-Holcomb Co.
Iowa, Des Moines (2) Electric Eng. & Const. Co.
Ky., Harlan (2) Hall Equipment Sales Co.
  Louisville (2) T. C. Coleman & Son
  Louisville (2) Williams Tractor Co.
  Paducah (1) Henry A. Petter Supply Co.
La., New Orleans (1) Ole K. Olson Co.
  New Orleans (2) Wm. F. Surgl Equipment Co.
Maine, Portland (1–2) Maine Truck-Tractor Co.
Md., Baltimore (1) Stuart M. Christhilf & Co.
  Baltimore (2) D. C. Elphinstone, Inc.
Mass., Boston, Allston (1–2) Clark-Wilcox Co.
  Cambridge (2) W. W. Field & Son, Inc.
Mich., Detroit (1) T. G. Abrams
  Detroit (2) W. H. Anderson Co., Inc.
  Dearborn (2) T. G. Abrams
  Flint (2) Gransden-Hall & Co.
  Muskegon (1–2) Lakeshore Machinery & Supply Co.
Minn., Minneapolis (1–2) Phillippi-Murphy Equipt. Co.
  St. Paul (1–2) D. L. O'Brien
Miss., Jackson (1–2) Jackson Road Equipment Co.
Mo., Clayton (1–2) The Howard Corporation
  Kansas City (1) Brown-Strauss Corp.
  Kansas City (2) Machinery & Supplies Co
  St. Louis (2) W. H. Reaves
Neb., Lincoln (1) Highway Equipment & Supply Co.
N. J., Hillside (2) P. A. Drobach
  Newark (1) Johnson & Dealaman
  North Bergen (2) American Air Compressor Corp.
N. M., Albuquerque (1–2) Bud Fisher Co.
  Roswell (2) Smith Machinery Co.
N. Y., Albany (1–2) Milton-Hale Machinery Co.
  Buffalo (2) Dow & Co., Inc.
  New York (2) Air Compressor Rental & Sales
  New York (1–2) Hodge & Hammond, Inc.
  New York (1–2) Railroad Materials Corporation
  Olean (2) Freeborn Equipment Co
N. C., Raleigh (2) Carolina Tractor & Equipment Co.
  Raleigh, (1) Smith Equip. Co.
N. D., Fargo (1–2) Smith Commercial Body Works, Inc.
O., Cincinnati (1–2) Finn Equipment Co.
  Cleveland (2) S. M. Clancey
  Cleveland (1) H. B. Fuller Equipment Co.
  Cleveland (2) Gibson-Stewart Co.
  Marietta (2) Northwest Supply & Equipment Co.
  Toledo (2) M. W. Kilcorse & Co.
Oregon, Portland (2) Andrews Equipment Service
Pa., Allentown (2) H. N. Crowder, Jr., Inc.
  Easton (2) Sears & Bowers
  Oil City (2) Freeborn Equipment Co.
  Philadelphia (1) Giles & Ransome
  Philadelphia (2) Metalweld, Inc.
  Pittsburgh (2) Atlas Equipment Corp.
  Wilkes-Barre (2) Ensminger & Co.
  Wilkinsburg (1) Arrow Supply Co.
S. C., Columbia (1–2) Smith Equipment Co.
Tenn., Knoxville (2) Wilson-Weesner-Wilkinson
Tex., Dallas (1–2) Shaw Equipment Co.
  El Paso (2) Equipment Supply Co.
  El Paso (1) Mine and Smelter Supply Co.
  Houston (2) Dye Welding Supply Co.
  Houston (1) McCall Tractor & Equipment Co.
  San Antonio (2) Patten Machinery Co.
  San Antonio (1) San Antonio Machine & Supply Co.
Utah, Salt Lake City (1–2) Landes Engineering Co.
Vt., Barre (1–2) A. M. Flanders, Inc.
Va., Richmond (1–2) Highway Machinery & Supply Co.
Wash., Seattle (2) Star Machinery Co.
  Spokane (2) Andrews Equipment Service
W. Va., Charleston (1) Clyde P. Beckner, Inc.
  Fairmont (2) Interstate Engineers & Constr., Inc.
Wyoming, Cheyenne (2) Wilson Equipment & Supply Co.

Buy Blue Brutes

Worthington Pump and Machinery Corp.

Worthington-Ransome Construction
Equipment Division
Holyoke, Massachusetts

Manufacturers' Activities

TROWBRIDGE A. WARNER has been appointed sales manager of Hendrick Manufacturing Co., Carbondale, Pa. Mr. Warner was formerly sales manager of the Register and Grille Manufacturing Co., Brooklyn, N. Y., and before that held a similar post with Tuttle & Bailey Manufacturing Co. Hendrick manufactures grilles, perforated metal screens, open steel flooring, grids and treads.

APPOINTMENT of four new distributors of Osgood and General Excavator construction, excavating and materials handling equipment is announced by M. C. McNeil, president of The Osgood Co. and The General Excavator Co., both of Marion, Ohio.

The General Machinery Co., Spokane, Wash., will provide sales, maintenance and warehouse service in The Inland Empire region. American Equipment Corp., with headquarters at Harrisburg, has taken over the combined Osgood-General franchise for several Pennsylvania counties. The central Iowa territory will be served by The Carl R. Miller Tractor Co., Des Moines. J. S. Innes, Ltd., of Leaside, Ont., will handle the eastern Ontario franchise.

F. D. HABERKORN has been appointed manager of the sales training division of the Caterpillar Tractor Co., Peoria, Ill. J. W. Mohler, formerly district representative at Dallas, Tex., has been named assistant sales manager of the central division, according to W. K. Cox, assistant general sales manager for the company.

J. W. Mohler

Mr. Haberkorn, a graduate of the Kansas State Agricultural College, has been with Caterpillar since 1935. Mr. Mohler, who joined the company the same year, is a graduate of the University of Illinois.

SCHRAMM INC. has opened a new office at 116 New Montgomery St., San Francisco 5, Calif., under the supervision of Henry S. Bartholomew who has considerable engineering background and experience. He will be available to extend cooperation to the users of compressed air and pneumatic tool equipment.

WALTER P. SCHWARM, sales manager of the Milcor Steel Co., Milwaukee, Wis., subsidiary of Inland Steel, has been elected vice-president in charge of sales. Starting as a worker in the Milcor plant in 1919, Mr. Schwarm was later employed in the cost, billing and order departments. When the company established a new branch in Chicago in 1923 he was transferred for work in that city. He later traveled extensively in the midwest handling dealer and jobber accounts. He was made assistant general sales manager in 1928 and general sales manager in February, 1944.

W. P. Schwarm

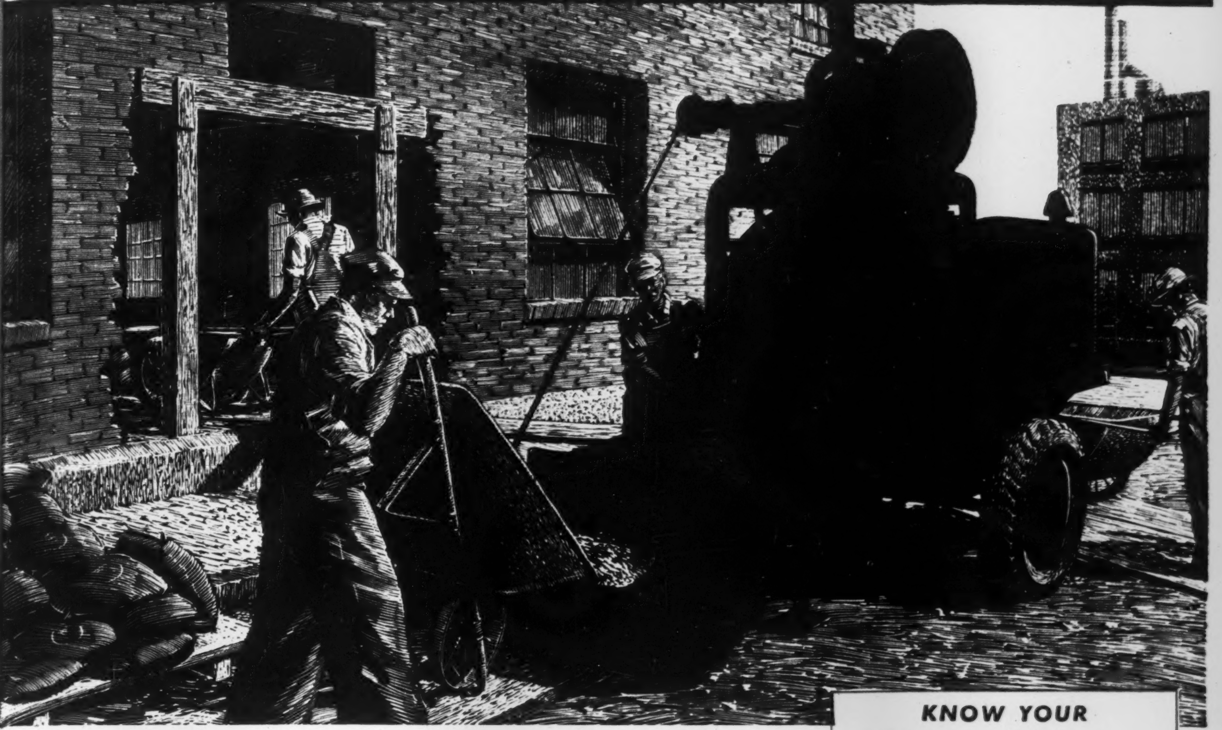
Succeeding Mr. Schwarm as general sales manager is Robert S. Schmieder who has returned to Milwaukee from the company's Baltimore branch. Mr. Schmieder has been with Milcor for 27 years, having started as a clerk in the factory. He later traveled as a company representative in Missouri and Illinois, after which he became assistant manager and then manager of the company's metal ceiling and specialties division. In February, 1939, he was made manager of the newly established Baltimore branch. Just before returning to Milwaukee he saw the completion of the company's new plant in Baltimore, including a modern and efficient steel warehouse.

R. S. Schmieder

The position vacated by Mr. Schmieder at Milcor's Baltimore branch is filled by H. Vernon Stehl.

H. V. Stehl

BETTER CONCRETE FROM ACCURATE WATER CONTROL



Only Ransome Blue Brute mixers, large and small, have all metal spiral cut-offs in the water tank and non-by-passing valves for accuracy of water measurement throughout the life of the mixer.

There are many other reasons why Ransome Blue Brute Mixers have the reputation of making the best concrete at the lowest over-all cost, such as the famous Ransome mixing action perfected during 95 years' experience. The drum tracks of all Ransome mixers are made of high carbon steel for maximum resistance to wear; machined to a true circle after being welded to the drum. Drum rollers of tough car wheel metal, are equipped with double Timken bearings for permanent alignment to assure a smooth-running, long-lived machine with minimum maintenance.

For further details, read Bulletin *No. 181,* available from your nearby Worthington-Ransome Dealer or Blue Brute headquarters.

RS-16

BUY BLUE BRUTES

KNOW YOUR

BLUE BRUTES

Your Blue Brute Distributor will gladly show you how Worthington-Ransome Blue Brute construction equipment will put your planning on a profitable basis and prove that *there's more worth in Worthington-Ransome.* Act now! His **name is listed on p. 130. The** number beside his name indicates the Blue Brutes he handles.

1.

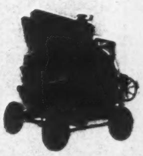
Blue Brutes include: Pavers, Concrete Spreaders**, Concrete Mixers, Concrete Placing Equipment, Big Mixers, Finishing Machines**, Pneumatic Placing & Grouting Equipment, Truck Mixers, Plaster & Bituminous Mixers, and accessories.

2.

Blue Brutes also include: Diesel, gasoline and electric driven Portable Compressors from 60 to 500 cu. ft. capacity in mountings to suit all jobs; Rock Drills and Air Tools in a wide range of weights and sizes; Contractors' Pumps.**

**Postwar Products

Truck Mixers
Capacities:
2, 3, 4½, 5½ cu. yds.



Portable Mixers
Capacities:
3½, 7, 10, 14 cu. ft.

Big Stationary Mixers
Capacities:
28, 56, 84, 126 cu. ft.

Pneumatic Placer
Capacity:
7, 14, 28 cu. ft.

WORTHINGTON

Worthington Pump and Machinery Corporation, Worthington-Ransome Construction Equipment Division
Holyoke, Mass.

Air Express speeds
the day she'll listen to
HER NEW RADIO

Yes, as industry races against time to make more and more radios, irons, washing machines and other goods the public wants and needs, Air Express is helping to get them faster.

Here's how. When a plant makes production changes, new tools, dies, machinery and parts are needed *fast*—critical material that is obtained via Air Express in a matter of hours. With such delivery speed, industry as a whole is gaining millions of man-hours in getting consumer goods back on the market and into the home.

Specify Air Express-a Good Business Buy

When time means man-hours saved, production gained, a customer made — Air Express "earns its weight in gold" as thousands of firms, large and small, have learned.

Shipments travel at a speed of three miles a minute between principal U. S. towns and cities, with cost including special pick-up and delivery. Same-day delivery between many airport towns and cities. Rapid air-rail service to 23,000 off-airline points in the United States. Service direct by air to and from scores of foreign countries.

TYPICAL RATE CHART

AIR MILES	2 lbs.	5 lbs.	25 lbs.	40 lbs.	Over 40 lbs. Cents per lb.
149	$1.00	$1.00	$1.00	$1.40	3.5
349	1.04	1.25	2.63	4.20	10.5
549	1.11	1.52	4.38	7.00	17.5
1049	1.26	2.19	8.75	14.00	35.
2349	1.65	4.03	20.13	32.20	80.5
Over 2350	1.68	4.20	21.00	33.60	84.

AIR EXPRESS

AIR EXPRESS

GETS THERE FIRST

Write today for "Jig Saw Puzzle," a booklet packed with facts that will help you solve many a shipping problem. Air Express Division, Railway Express Agency, 230 Park Avenue, New York 17. Or ask for it at any Airline or Express office.

Phone AIR EXPRESS DIVISION, RAILWAY EXPRESS AGENCY
Representing the AIRLINES of the United States

whose new title is district sales manager. Mr. Stehl traveled as a Milcor representative for a number of years before the war. Previous to his association with Milcor he was employed in sales and engineering capacities by other companies in the steel building field.

LIEUT. FRANKLIN P. CLARK, recently of the Navy Bureau of Supplies and Accounts, has been appointed sales manager of The Upson-Walton Co., Cleveland, Ohio, manufacturer of wire rope, fittings, tackle blocks and brattice-cloth. Lieutenant Clark's wartime job was the procurement of wire rope and other critical materials for the Navy. Prior to that he was associated with The Jones & Laughlin Steel Corp., Pittsburgh, where he helped launch its wire rope sales program in the New York, Baltimore and Boston areas. He was also a wire rope salesman, sales manager of the Buffalo district and assistant sales manager of the eastern district, successively, for the Wickwire Spencer Steel Co., New York.

HARRY G. HOWELL, forging specialist and an authority on factory management, is the new vice president of Tube Turns, Inc., Louisville, Ky., in charge of production.

A native Kentuckian, Mr. Howell returns to the Bluegrass after four years as head of Oldsmobile's plant and a total of twenty-two years' association with General Motors. Born in Kilgore, Ky., he attended Purdue and began his career with GM's Buick Division.

E. J. GARRIGAN, formerly vice-president and factory sales manager, has been appointed vice-president in charge of sales and will direct all sales activities of The Okonite Co. and its Hazard Insulated Wire Works division, and of its affiliate, The Okonite-Callender Cable Co., Inc. Mr. Garrigan, a director of the company, who joined the Okonite organization in 1924 and who has been connected with the electrical wire and cable industry for over 40 years, will be located at the company's executive offices in Passaic, N. J.

C. E. Brown, Jr., formerly vice-presi-

BACK AGAIN

GOOD NEWS!

ECONOMICAL W-SPEED PATROL

ALLIS-CHALMERS

LIMITED QUANTITY *Order Now!*

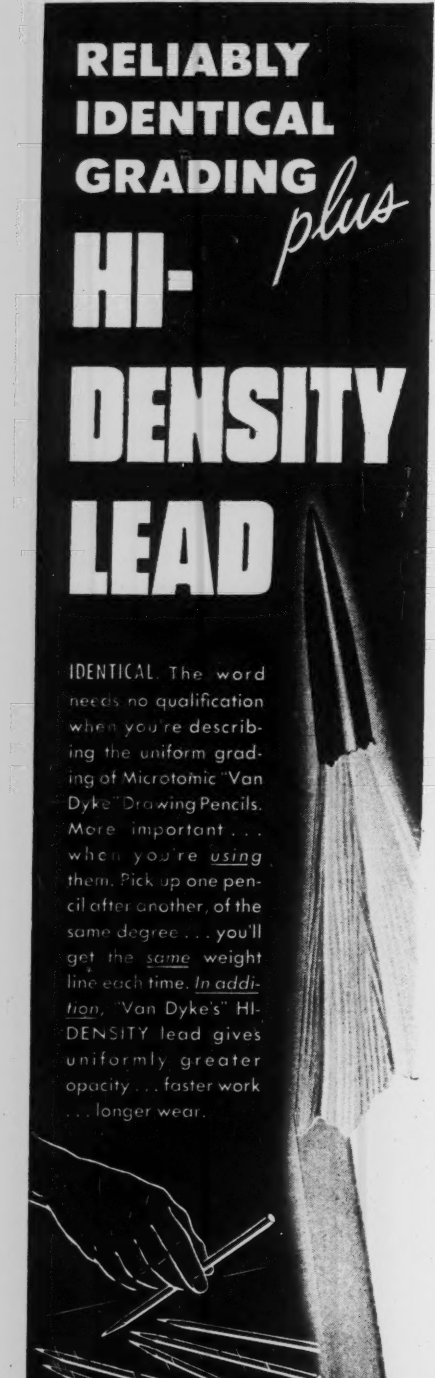
Now you can put those worn-out roads and streets in smooth, easy-riding condition. Economical W-Speed Patrols are again available . . . but in limited quantity. An early order will bring early delivery . . . so act now.

Wire, write or call your Allis-Chalmers dealer at once!

Powerful for its size, the W-Speed Patrol easily handles regular maintenence and light construction — at a fraction of ordinary cost. Works at 3 to 5 m.p.h.—on less than a gallon of fuel an hour. Short-turning radius speeds every job — a big advantage in narrow quarters. Equipped with electric lights and starter. Available with broom or snow plow . . . drawbar always accessible.

ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.


RELIABLY IDENTICAL GRADING *plus* HI-DENSITY LEAD

IDENTICAL. The word needs no qualification when you're describing the uniform grading of Microtomic "Van Dyke" Drawing Pencils. More important . . . when you're *using* them. Pick up one pencil after another, of the same degree . . . you'll get the *same* weight line each time. *In addition*, "Van Dyke's" HI-DENSITY lead gives uniformly greater opacity . . . faster work . . . longer wear.

MICROTOMIC
VAN DYKE
DRAWING PENCILS

The EBERHARD FABER Drawing Pencil in 18 degrees, 7B to 9H - plus 6 degrees with special Chisel Point Leads

dent in charge of the company's Washington, D. C., office, has been appointed vice-president and general sales manager to coordinate the executive offices in Passaic, N. J., with the 18 branch offices. Mr. Brown, who will have offices at Passaic, N. J., and the New York district sales office, has been connected with the Okonite sales organization since 1919.

Isaac Fogg has been elected president of Atlas Powder Co., succeeding Leland Lyon who resigned as president and member of the executive committee, but remains as chairman of the board. Mr. Fogg started with Atlas in 1913 as confidential secretary in the office of the secretary-treasurer. He became assistant secretary and assistant treasurer in 1917, treasurer and member of the board in 1927, and vice-president in 1931.

F. S. Pollock, general manager of the explosives department, has been elected vice-president. He entered the explosives industry in 1909 at Reynolds Works of the Potts Powder Co., later acquired by Atlas. After various assignments in Atlas explosives plants, he became works manager of the nitrate plant, Perryville, Md., in World War I. He was director of high explosives manufacturing operations in 1927, becoming director of the government ordnance works department in 1942 and general manager of the explosives department later that year.

Barber-Greene Co., Aurora, Ill., has expanded its sales organization by appointing sales managers for the New York and Canadian sales areas.

Capt. Earle F. Lamprey, until recently at Camp Claiborne, La., where he supervised construction and maintenance work, is placed in charge of the New York area. Until headquarters can be established, he is serving the territory from the Barber-Greene Boston office.

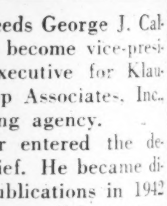
Ralph Dano, recently released by the War Production Board, where he was on leave from Barber-Greene as deputy director, construction machinery division, now heads Barber-Greene sales activities in Canada at Toronto. Before going with WPB, Dano was a Barber-Greene sales engineer, and has been with the company since 1923.

Other Barber-Greene area sales managers are L. A. Larson, Minneapolis, Minn.; B. E. Lindstrom, Aurora, Ill.; E. L. Benson, San Francisco, Calif.; E. H. Cooper, Dallas, Tex., and Tom Benbow, Atlanta, Ga.

The Wood-Ply Research Foundation, Inc., has been formed to develop and merchandise new plywood and plastic products.

Thomas J. Hilliard, who has been general manager of sales of Carnegie-Illinois Steel Co., since 1938, has been named vice-president in charge of sales. He has been succeeded by J. Douglas Darby, manager of sales in the Philadelphia area. A. Paul Selby has been promoted to assistant general sales manager, and Wesley C. Babbitt has been named manager of sales in the Philadelphia area.

Guy J. Goffey, who has been western manager of the Chicago Pneumatic Tool Co. in Los Angeles, Calif., has been transferred to New York, where he will be vice-president and general sales manager. He had been in Los Angeles since 1938 and has been associated with the company since 1935. Before that he was with the Black and Decker Electric Tool Co. Detroit, Mich.



Arthur R. Tofte has been named manager of the advertising and public relations department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis., by William C. Johnson, vice-president of the firm's general machinery division. Tofte has been a member of the department since 1938. He succeeds George J. Callos, who resigned to become vice-president and account executive for Klau-Van Pieterson-Dunlop Associates, Inc., Milwaukee advertising agency.

The new manager entered the department as copy chief. He became director of employe publications in 1942 and held that position until he was selected to head the department. Tofte was graduated from the University of Wisconsin in 1925. He was with several advertising agencies and was also advertising manager of the Sterling Motor Truck Co. He was a member of the Advertising department, Bucyrus-Erie Co., immediately before going to Allis-Chalmers.

REO—"A GOOD MIXER" IN ANY COMPANY

H. H. HALL
CONST.
349
H. H. HALL
CONST. CO.
EAST ST. LOUIS, ILL.
H. H. HALL
CONST. COMPANY
ST. LOUIS, ILLINOIS

Reo in highway construction work, equipped with 3-yard concrete mixer and air brakes.

SMASH HIGHWAY
TRADE BARRIERS
Demand reasonable state laws!

Reos are built and powered to travel in fast-moving company. They go hand in hand with modern construction equipment. They are helping to speed the completion of road building and other engineering projects in many sections of the country.

Reo trucks and tractors are long-time favorites in this field. In every chassis part they are engineered and built to carry the heavy loads, o travel the toughest roads and to get the job done in the shortest ime possible, at the lowest possible cost.

The powerful new Reos are the finest hauling units developed rom precision production for war. Ask your Reo dealer for details.

EO MOTORS, INC., LANSING 20, MICHIGAN
Factory Branches, Distributors and Dealers in Principal Cities

REO

1904 • AMERICA'S TOUGHEST TRUCK • 1945

STRENGTH TO WIN!

The mighty B-29 Super Fortress has typified Uncle Sam's leadership in the air. This great plane not only did its bombing job well, it also proved itself highly resistant to enemy attacks . . . a winning combination.

• • •

CLAY PIPE, too, has this winning combination. It carries sewage, surface and sub-surface drain water and, in addition, successfully stands up against pipe enemies year after year. Clay Pipe is impervious to acids, alkalies, industrial wastes, gases and abrasion — it never wears out!

No wonder more Clay Pipe is used in the United States than any other kind of sewerage or drainage material. Preference for Clay Pipe of leading engineers is shown in the survey of 123 of America's largest cities. Eighty-nine per cent of the cities' 37,219 miles of sewers are built of Clay Pipe.

Clay Pipe assures use of your installations by future generations . . . lower cost in the long run.

Write for information or engineering literature, and a conveniently located regional association office will serve you.

NATIONAL CLAY PIPE MANUFACTURERS, INC.
111 W. Washington St., Chicago 2, Ill.

C-1145-6

SPECIFY
CLAY PIPE
IT WILL PAY TO USE CLAY

Manufacturers' Publications

Excavating Equipment—The second in a series of booklets contains photographs of 3/8 to 2-1/2-yd. shovels, draglines, and cranes. The book's 36 pages describe the part excavating has played in building the modern standard of living. They tell how the dirt-moving industry prepared the ground work for defense in America, aided in the construction of advanced bases, and worked on the fighting fronts. The books shows how progress in the postwar period must start with excavation. —*Bucyrus-Erie Co., South Milwaukee, Wis.*

Diesel Tractor—The ability of a tractor to do a job is primarily dependent upon effective use of power, and construction that will do the job with a minimum of time out for maintenance and repairs.

A new 32-page catalog features a 113 drawbar horsepower tractor and the diesel engine that motivates it along with views of the product in action on many jobs.—*Caterpillar Tractor Co., Peoria 8, Ill.*

Coated Lens—Of a new coated lens for surveying instruments this manufacturer claims in a bulletin that brightness is increased by as much as 40 per cent and, in addition, image contrast is greatly improved. In the ordinary lens, it is estimated there is a 43 per cent light loss in an internal focusing telescope, commonly used in surveying. In the coated lens, light transmission is greatly increased, resulting in a brighter and sharper image.—*David White Co., 315 W. Court St., Milwaukee 8, Wis.*

Pipe Couplings—A bulletin graphically illustrates the simplicity of coupling parts and gives complete engineering data, drawings and specifications on the 11 sizes from 1¼″ to 16″. The couplings may be used for permanent or temporary repair of pipe lines and withstand all normal working pressures of gas, steam, oil and water.—*Drinkwater, Inc., 2323 South Michigan, Chicago 16.*

Prefabricated Steel Construction—This bulletin tells of a structural steel frame constructed of hot-rolled shapes which conform to the standard specifications of the American Society for Testing Materials. It is designed and fabricated in accordance with the stand-

Guide to

larger capacity... lowest operating costs with

TELSMITH

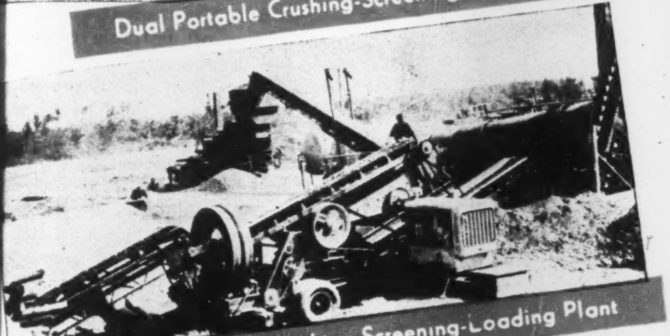
PORTABLE CRUSHING PLANTS

ELSMITH
PORTABLE CRUSHERS

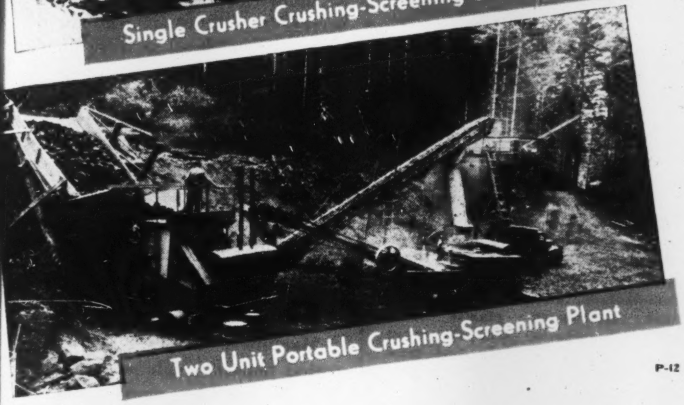
ET NEW PORTABLE CRUSHING CATALOG P-2

HAFERMAN & STARK, CONTR'S.
JORDAN, MINN.

Dual Portable Crushing-Screening-Loading Plant

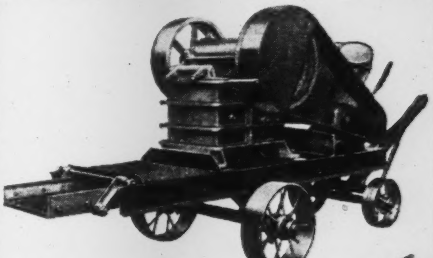


Single Crusher Crushing-Screening-Loading Plant

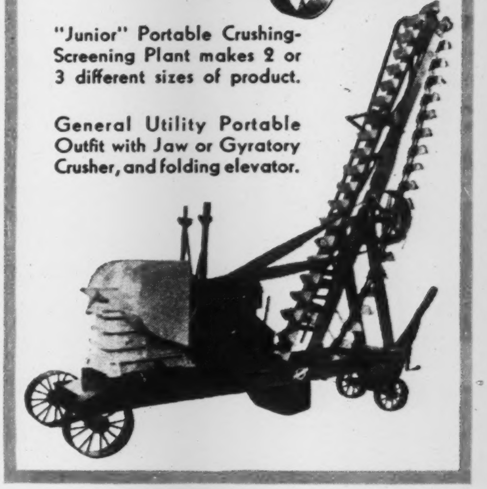


Two Unit Portable Crushing-Screening Plant

P-12



"Junior" Portable Crushing-Screening Plant makes 2 or 3 different sizes of product.



General Utility Portable Outfit with Jaw or Gyratory Crusher, and folding elevator.

ITH ENGINEERING WORKS, 500 EAST CAPITOL DRIVE, MILWAUKEE 12, WISCONSIN

Cable Addresses: Sengworks, Milwaukee—Concrete, London

51 East 42nd St.
w York 17, N. Y.

211 W. Wacker Drive
Chicago 6, Ill.

713 Commercial Trust Bldg.
Philadelphia 2, Pa.

247 Third Street
Cambridge 42, Mass.

Boehck Eqpt. Co.
Milwaukee 3, Wis.

Mines Eng. & Eqpt. Co.
San Francisco 4—Los Angeles 14

ndeis M & S. Co.
ouisville 8, Ky.

Rish Equipment Co.
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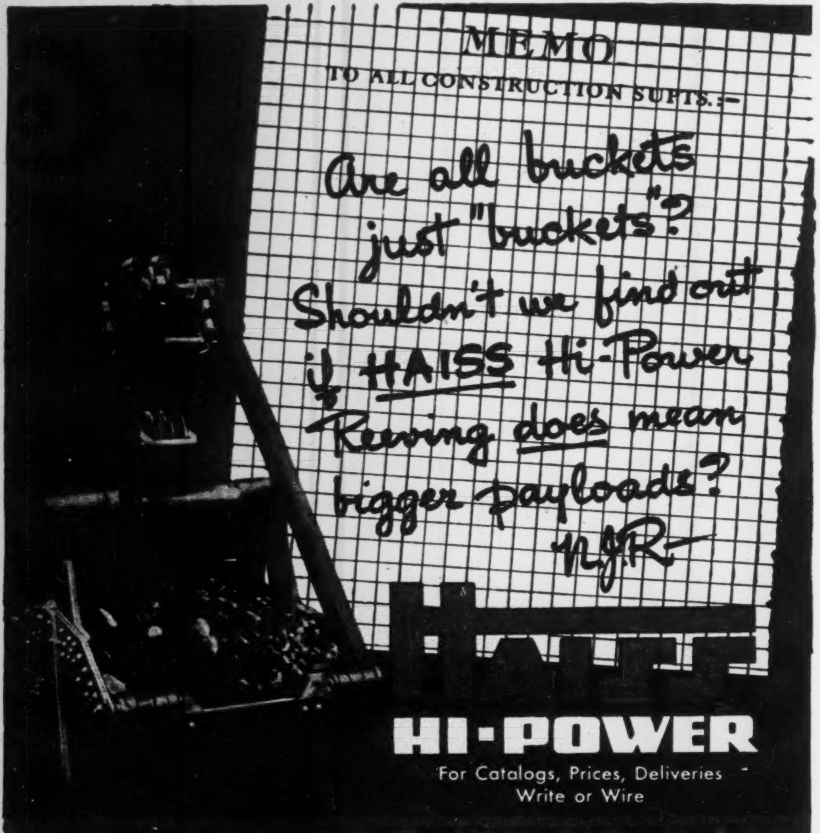
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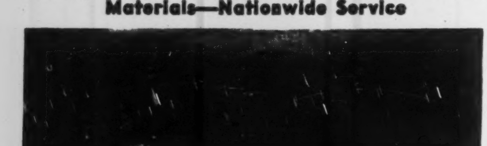

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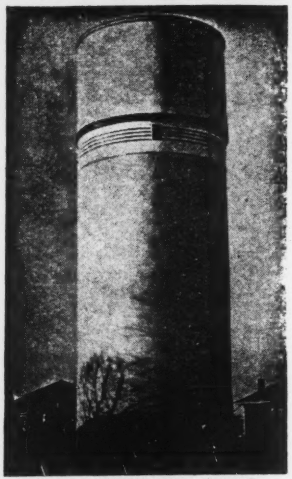

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ard practice of the American Institute of Steel Construction. In addition, the standard cover consists of especially fabricated galvanized steel sheets.

The bulletin contains many items of interest to erection engineers and executives.—*National Machine and Foundry Company, 313 Sixth Avenue, Pittsburgh 22, Pa.*

Pressure Castings—A folder describes a variety of pressure applications and illustrates faulty and correct design for pressure units.—*Meehanit Research Institute of America, 80 Pershing Square Building, New Rochelle, N. Y.*

Light-reflecting Floors—The peace time possibilities of the white-cement floor are held to be widespread, both for new floors and the retopping of old floors, particularly in factories, schools offices, libraries, hospitals, hangars stairwells, and basements. A 24-page book tells all about this and gives experience data to show that white-cement floors are easy to keep clean Sections of the book are devoted to recommended practice for floor construction, surface treatment and maintenance.—*Universal Atlas Cement Co Chrysler Bldg., New York, N. Y.*

Shovel Book—This catalog replete with halftone illustrations, gives a com plete review of desirable features look for in shovels and cranes a serves as a guide in selecting excavatin and material handling equipment— *Bay City Shovels, Inc., Bay City, Mi*

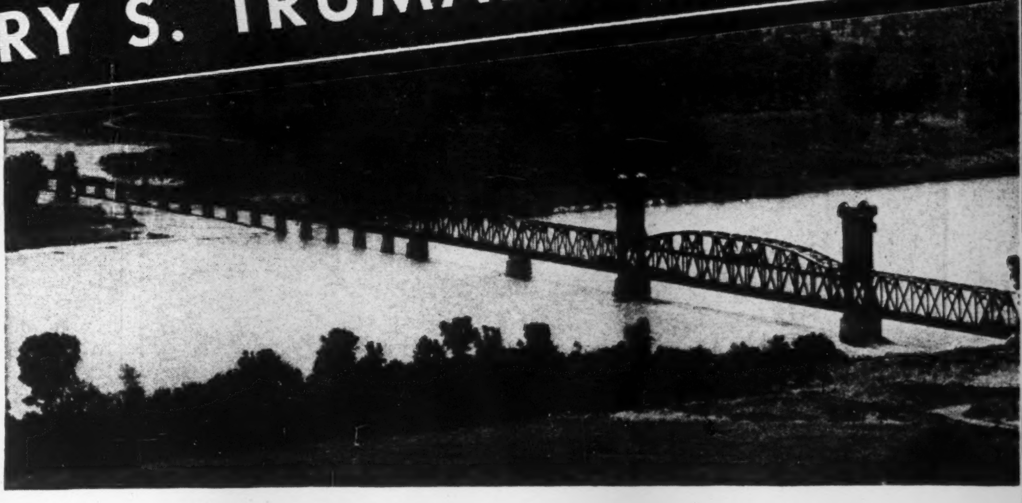
pH and Chlorine Control—A revis combination handbook and catalog co tains both simple and technical explana tions of the meaning of pH control; sp cific discussions of the application pH, chlorine and phosphate control 35 industries; the precautions to be served in making determinations; a descriptions of all outfits, including new sets. *W. A. Taylor & Co., 7 York Road, Baltimore 4, Md.*

Air-entrained Concretes.—A bulleti tells how to control the addition of a in air-entrained concrete to prevent l densities. Another booklet is a manu for using an air-entraining agent *Dewey and Almy Chemical Co., Ca bridge 40, Mass.*

Machines, Prices, Jobs—An illu trated booklet explaining the histori relation of jobs, machines and pri cites specific examples of how mode tools contribute to high level empl ment in service industries as well a manufacturing.—*National Machine T Builders' Association, Cleveland, Oh*

The 1,600-ton, 420-foot long vertical lift span in its raised position provides a channel width of 400 feet and a vertical clearance above low water of 70 feet for navigation. In its closed position the normal clearance above low water is 34 feet, so that the total movement of the span is 36 feet. The three story operating house may be seen on the right-hand pier.

NEW TYPE LIFT SPAN FEATURES HARRY S. TRUMAN BRIDGE



he bridge consists of three 250-. through truss spans, one 420-. through truss vertical lift an. 18 deck plate girder spans f 78 feet and one plate girder an of 45 feet. It was designed nd the construction supervised y Howard, Needles, Tammen & ergendoff, consulting engineers.

THE HARRY S. TRUMAN BRIDGE crossing the Missouri River at Kansas City, Mo., is the major element of an outstanding railroad relocation project. Undertaken jointly by the Chicago, Milwaukee, St. Paul & Pacific Railroad Company and the Chicago, Rock Island & Pacific Railway Company, it provides a more direct routing of rail traffic through Kansas City, and permits faster-scheduled operations for transport to the West Coast.

This imposing bridge, first opened to traffic on June 1, 1945, is a single track structure with a total length of 2,633 feet. Its dominating 420-foot vertical lift span over the navigation channel is electrically operated by remote control from a 3-story operating house located on one of the end piers. A gasoline power unit is available for emergency operation in case of electrical power failure.

The unusual features and engineering developments which are embodied in the design and construction of the Harry S. Truman Bridge, contribute to the lasting strength and ruggedness demanded by today's and tomorrow's heavy freight tonnage, great traffic density, and high speed operations.

The completed ready-for-traffic superstructure—including all structural steel; sheaves, ropes, counterweights, machinery, electrical equipment and housings for operating the lift span; laying of ties, tracks, footwalks and railing for the completed railway deck—was under contract to American Bridge Company.

War projects such as this point the way to the postwar problems facing America's railroads — for "better railroading" is here to stay. And when their postwar plans of roadbed rehabilitation shape up, American Bridge will be prepared to meet their every structural need.

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Men and Jobs

Brig. Gen. Patrick H. Tansey, who was assistant engineer commissioner in Washington, D. C., from 1936 to 1940, has been given a Distinguished Service Medal "for exceptionally meritorious and distinguished services in the performance of duties of great responsibility from March, 1942, to June, 1945". General Tansey is now in Japan but before last June was on duty in the operations division in the office of the Chief of Staff, concerned with the problems of supply.

James Wise is supervising maintenance engineer for buildings, grounds, structures and airfields for the Alaskan mainland and the Aleutian Islands, with headquarters at Port Richardson, Alaska. He was one of the original group of civil engineers transferred to Alaska in 1940 for garrison and airfield construction. Prior to that he served for five years in various engineering capacities on construction of Boulder Dam, the Colorado River aqueduct, and the Boulder transmission power lines.

J. Ray Wilson, with the North Carolina State Highway Commission for many years as associate bridge construction engineer, and recently with U. S. Navy, has entered the contracting business under the name of J. Ray Wilson, Salisbury, N. C.

Lieut. Col. Alexander Brest, Jacksonville, Fla., contractor and construction engineer and secretary-treasurer of the Duval Engineering and Contracting Co., has joined the J. P. Riddle Co. of Miami, after three years with the Army Air Forces. Colonel Brest is now on his way to Brazil, where he will map plans for an aviation engineer school at Escola Tecnica.

J. A. Trader has been appointed designer of bridges and culverts for Jefferson County, Ala.

J. M. Evans, Morris, Minn., has been appointed chief of a new county division of the Minnesota State Highway Department. He will serve as coordinator between the highway department d county authorities in connection h county road projects financed with te and federal aid.

George M. Foster, of East Lansing, ch., has been appointed bridge engi- r for the Michi- n State High- y Department.

Mr. Foster was duated from University of chigan in 1922 h a bachelor of ence degree, ving specialized structural engi- ring. He imme- tely entered the employ of the bridge ision of the highway department, ving successively as office engineer, ftsman, inspector, resident engineer, igner, and chief draftsman, and assistant bridge engineer.

In May, 1935, he resigned to become ociated with the Yeager Bridge & lvert Works of Port Huron, and be- a private consulting engineer prac- e. During the last 10 years he has ved as consulting engineer in bridge road construction work to a large mber of cities and county road com- sions. He designed a number of ctures for the recently completed roit Industrial Expressway-Willow n System.

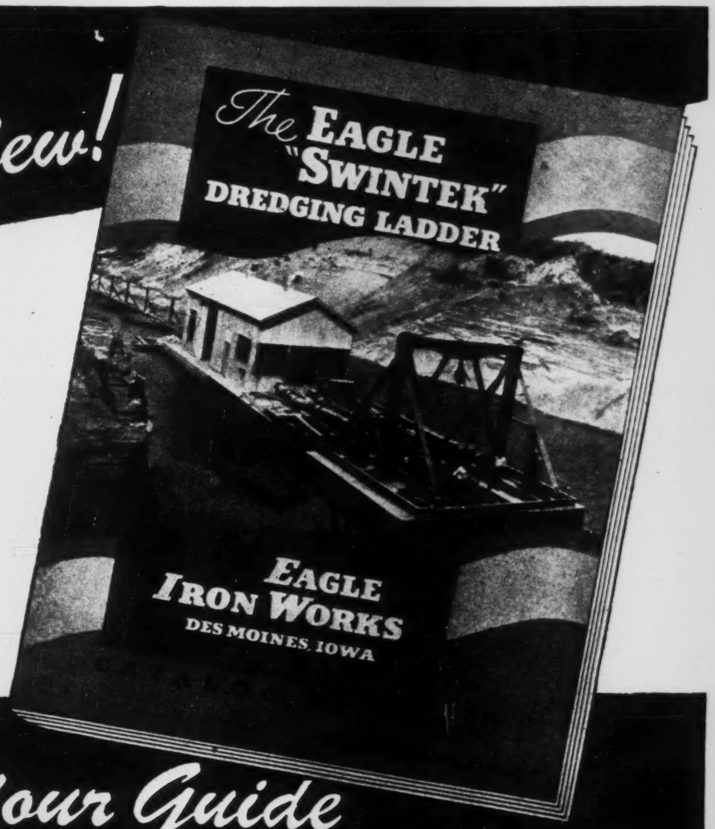
. C. Linberg, city engineer of Bur- gton, N. C., for the last 25 years, on a t time basis, has resigned and **H. M. rrison,** Burlington, has been ap- nted to succeed him as full time ineer.

James G. Cooney is now acting as nton County superintendent of high- s at Carlyle, Ill. He replaces **War- B. Goodell,** who has gone to Salem, , to assume the position of Marion nty superintendent of highways.

Prentice White, administrator of the nnecticut State Housing Authority, been named a vice chairman for nnecticut on the National Commit- of Economic Development. Mr. ite will work toward cooperation h local builders, architects and de- ers for early planning of private struction and the quick completion construction surveys.

apt. William M. Angus, Jackson- e, Fla., civil engineer and now with Civil Engineer Corps, U. S. Navy, received the Legion of Merit for his ceptionally meritorious services" in struction of 16 naval bases from Aus- ia to the Philippines. He is now erintending civil engineer of the y's Area 2, in New York.

New!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